



APRIL 1960

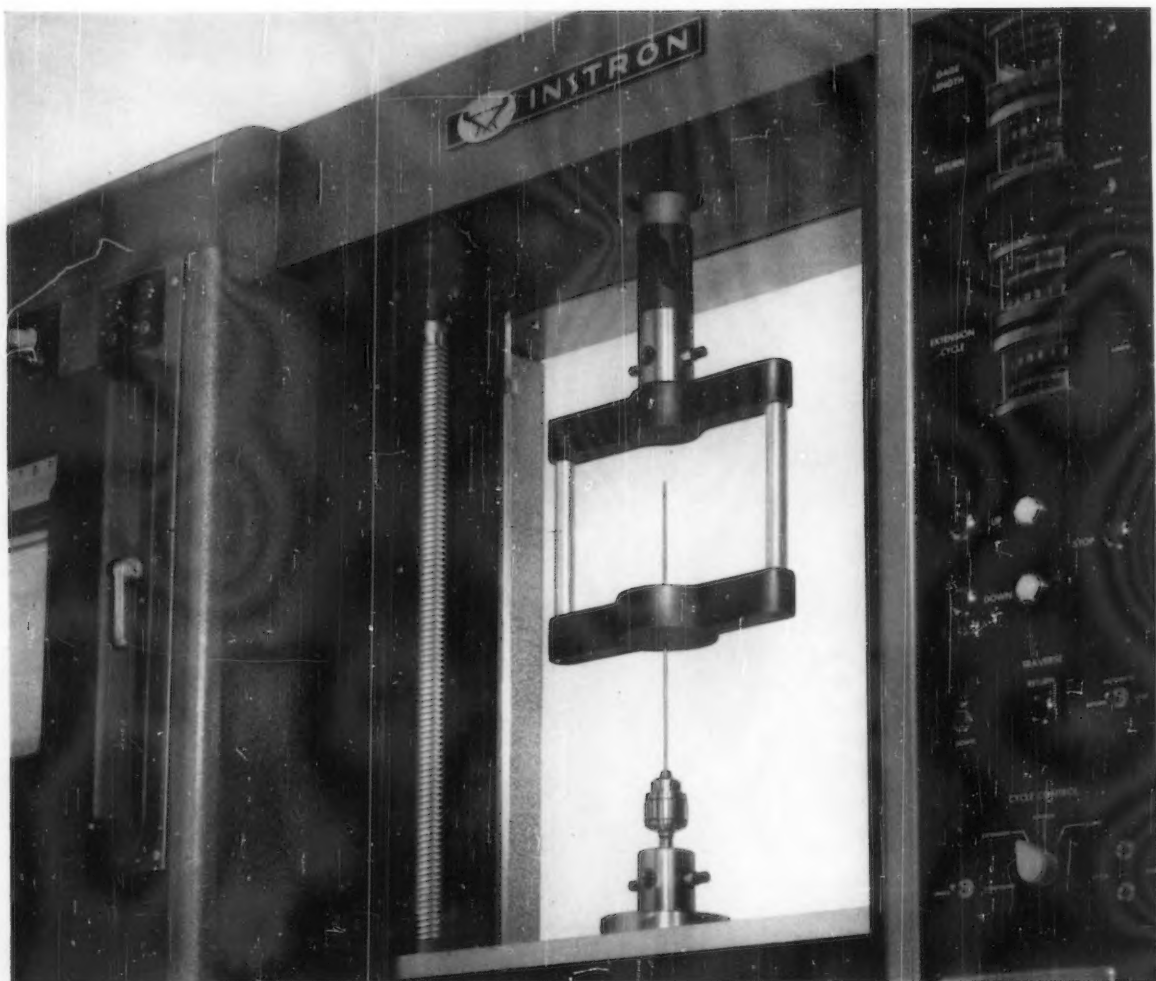
No. 245

Bulletin

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American Society for Testing Materials
RESEARCH AND STANDARDS FOR MATERIALS

EDITORIAL DEPARTMENT
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ASTM BULLETIN

April 1960

Number 245

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TECHNICAL PAPERS

- Tests for Potential and Past Moisture Expansion of Ceramic Building Units—E. H. Waters, J. S. Hosking, and H. V. Hueber. *Tests for white-ware proposed by Schurecht and modifications for burnt clay building units proposed by McBurney are critically examined*..... 55
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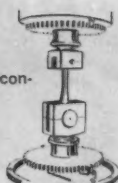
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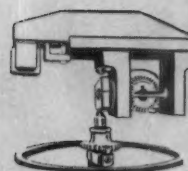


For smooth or profiled wires for aerial ropeways, conveyors, lifts, etc.

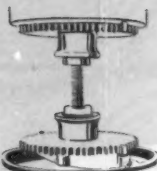
For automobile connecting rods.



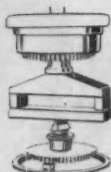
For spot-welded joints and rivets under alternating or fluctuating loads.



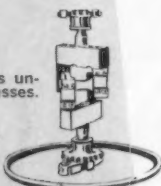
For gear testing under actual conditions. Torsion bending, tooth pressure, etc.



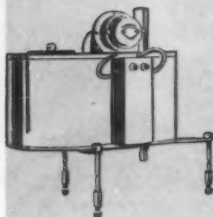
For notched bars and components with notches, such as screws stepped bars, shafts with transverse holes, etc.



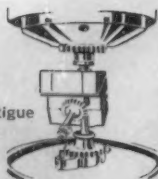
For transverse tests on welded, riveted bolted plates, etc.



For torsion tests on alternate stresses.



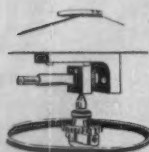
For testing at sub-normal temperatures ... to -320°F .



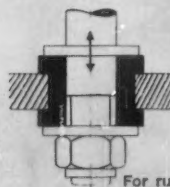
For testing at elevated temperatures... up to 1500°F maintaining static preload, through accurate load maintainers, when plastic flow occurs.



For bending fatigue on a gear tooth.



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MI-8 THERMOBALANCE

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- Dry oxidation of metals and alloys
- Solid system changes accompanied by addition or loss of gas or vapor
- Dissociation of true chemical compounds formed when a gas is absorbed by a solid
- Thermal data on the calcination of precipitates
- Drying products in powder form

MI-9 MICROPENDULUM "COULOMB"

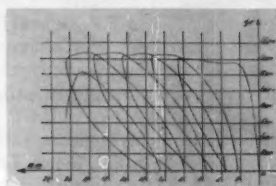
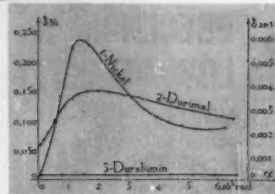
Specially designed for a specific field of testing, the MI-9, through attenuated oscillations, determines:

- The variations of internal friction in metals
- Magneto-elastic anomalies of metals and ferromagnetic alloys
- Changes of internal friction due to cold working
- The mechanical hysteresis and fatigue of metals.



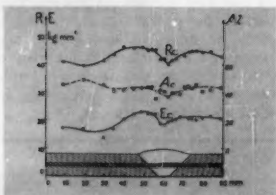
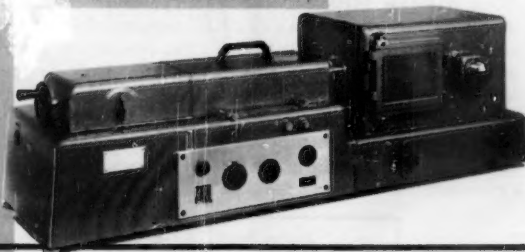
MI-9

Curves plotted by evaluating the damping diagrams. On the Nickel and Durinval curves the magneto-elastic anomalies inherent to ferromagnetic materials is clearly defined. The very slight decrement of Duralumin is so-to-say independent of the amplitude.



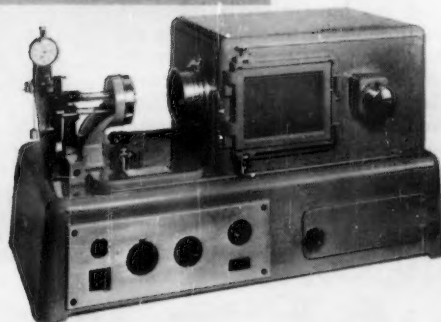
MI-44

Load-deformation curves of flat, colorless extruded polyethylene, employing a 3 kg. maximum capacity dynamometer.



MI-34

Detailed investigation of a weld made by carrying out Micro Shearing tests. A Chromium-Molybdenum steel welded with an electrode of the same material.



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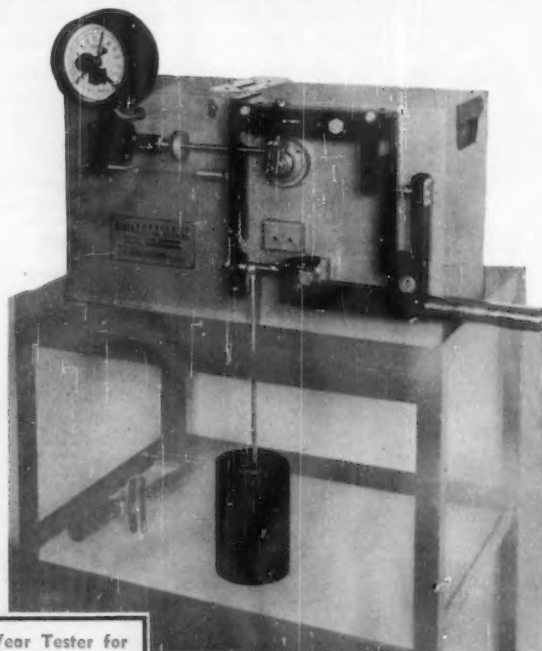
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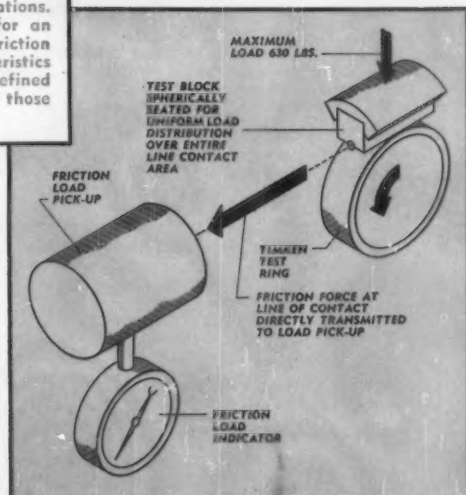
Admittedly the greatest single handicap in boundary lubricant research has been the lack of tools in the form of accurate and reliable bench test equipment. The stark oversimplification of E.P. testing equipment contrasts sharply with the complexity of friction and wear phenomena. The Alpha Model LFW-1 is the result of a search for an "intermediate" between the oversimplified E.P. Bench Test and costly and time consuming full scale performance tests. Such intermediates, of which many are needed, cannot fail to sharply reduce the terrific waste of research expenditure and talent.

Since all E.P. lubricity ingredients function effectively only in a limited temperature range, E.P. Bench Tests must either measure frictional contact temperature or, pending the development of means to do so, simulate them. Sliding velocity is one important factor in this simulation. A large group of E.P. lubricity ingredients which are highly successful in industrial low velocity mechanisms completely fail to respond on most E.P. testers because excessive velocities and loads combine to produce frictional temperatures beyond the functional temperature range of the E.P. ingredient.



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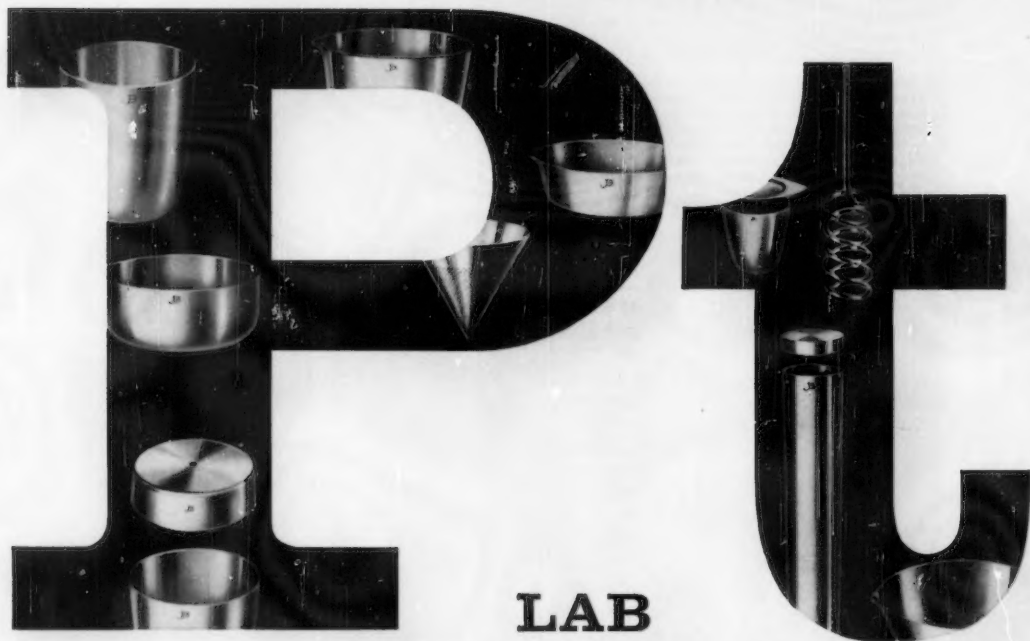
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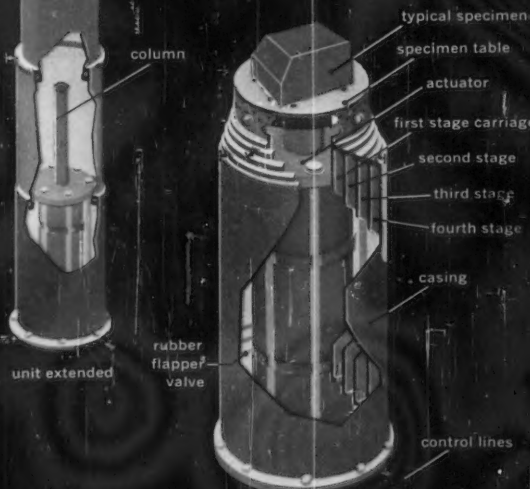
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dynamic loading

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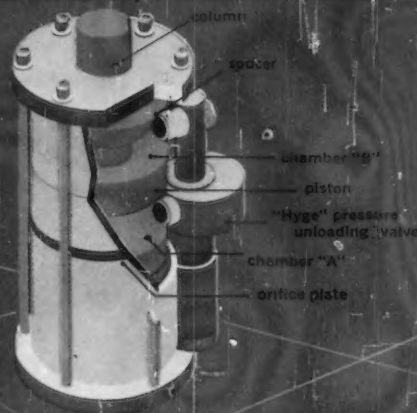
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Imparts long duration shock impulses to heavy specimens, such as missile nose cones. It consists of a HYGE actuator and four concentric tubes with integral water cushion for deceleration. Unique design results in "clean" wave form, and absence of undesirable transients. Maximum rated thrust, 180,000 lbs. Height extended, 18 ft.



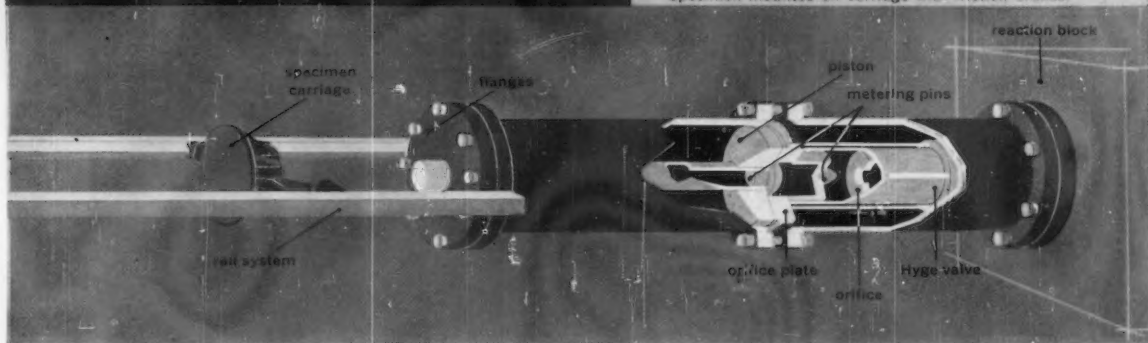
MODEL/334 • FORCE-TIME TEST FACILITY

This machine imparts a predetermined force-time impulse to a test article with external control of force level, rise time, dwell, and decay. Typical applications: to simulate the effects of a nuclear explosion upon building foundations, to simulate stresses in a rocket engine test stand. Dwell time may vary from fractions of a millisecond to several minutes. Rise and decay times, on the order of 200 milliseconds.



MODEL/347 • SHOCK-TEST FACILITY

This machine provides great versatility and control of g level, duration, wave form, and specimen mass. It can produce, for example, a 3000 g short time peak, followed by a 1/4 cosine impulse. Typical application, simulation of 2-phase water re-entry shock. Rated maximum thrust, 450,000 lbs. External deceleration by a 60 ft. rail system. Specimen mounted on carriage with friction brakes.



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ASTM BULLETIN

Research and Standards for Materials

Number 245

April 1960

63rd Annual Meeting

Atlantic City, N. J. June 26-July 1, 1960

New Materials Sciences Division to sponsor first two symposia. Full program includes 15 additional symposia and technical sessions. More than 50 technical committees plan to meet.

FEW AREAS of materials research and standards will be left untouched during the week of the Society's 63rd Annual Meeting. The staple fare, as always, will be the work of polishing, modernizing, and supplementing the all-important ASTM standards, which will be the main item of business in meetings of more than 50 technical committees.

Those who attend the numerous technical sessions and symposia will be brought up to date in the various fields of materials technology to be covered, and will have the chance to see, hear, and talk with the leaders in those fields. The luncheons will afford members and guests an opportunity to relax in a social atmosphere that includes men from all over the nation having interests and problems similar to their own, and to hear stimulating addresses on topics of broad interest and timeliness.

Symposia

The technical program includes nine symposia:

**Recent Progress in Materials Science
Nature and Origin of Strength of Materials**

Acoustical Fatigue

Shear and Torsion Testing

**Present Methods of Metallographic
Specimen Preparation**

**Nuclear Methods for Measuring Soil
Density and Moisture**

**Radiation Effects and Radiation Do-
simetry**

**Low Temperature Properties of High
Strength Aircraft and Missile Ma-
terials**

Quality of Observations

Technical Sessions

In addition to the symposia, there will be sessions on the following subjects:



**Concrete
High Temperature
Soils for Engineering Purposes
Fatigue
Metals
Low Cycle Fatigue
Road and Paving Materials
Cement and Plaster**

Lectures

The Annual Edgar Marburg Lecture will be presented by Dr. Farrington Daniels, professor emeritus of chemistry, University of Wisconsin, and vice-president of the National Academy of Sciences. His subject: Solar Energy.

Dr. R. Carson Dalzell, assistant to the director, Division of Reactor Devel-

opment, Atomic Energy Commission, will present the annual Gillett Lecture on the subject of Nuclear Fuel Element Development.

Materials Sciences Program

The technical agenda all day Monday will be devoted to a program developed by the Society's new Division of Materials Sciences. The morning session will be devoted to a "Symposium on Recent Progress in Materials Science." The afternoon session will be devoted to a "Symposium on the Nature and Origin of Strength of Materials."

Between the morning and afternoon sessions, there will be a Materials Sciences Luncheon at which Dr. W. O.

The Provisional Program . . .

of the 63rd Annual Meeting, which begins on page 18, is designed to give a comprehensive preview of the symposia, sessions, and special events of the meeting. Included are brief abstracts of the papers to be given, and statements of the scopes of the symposia.

The official program given to registrants at the meeting will contain full and final details of the sessions, a complete schedule of committee meetings, and the when and where of social features of the week.

Baker, vice-president—research, Bell Telephone Laboratories, Inc., will be the speaker. Dr. Baker is a representative of the President's Science Advisory Committee on national policy for materials research and development. It is expected that his remarks will touch upon the establishment of interdisciplinary laboratories at certain universities and on research and education relating to materials science.

President's Luncheon

The annual President's Luncheon will be held on Tuesday noon, June 28. At this time, the retiring president, Frank L. LaQue, will present the President's Address. New honorary members will be introduced and Society awards will be presented. Recognition will also be given to 40- and 50-year members of the Society.

Committee Meetings

A detailed schedule of technical committee meetings will be included in the program distributed at the Annual Meeting. An advance tentative outline of the meetings was included in the April 4 letter to members. As that letter states, members should consider the committee meeting schedule to be tentative; the official notice for committee and subcommittee meetings will be issued by the secretary of each committee. As we go to press, the following committees plan to meet:

- A-1 Steel
- A-3 Cast Iron
- A-5 Corrosion of Iron and Steel
- A-6 Magnetic Properties
- A-10 Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys
- B-2 Non-Ferrous Metals and Alloys
- B-3 Corrosion of Non-Ferrous Metals and Alloys
- B-4 Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts
- B-5 Copper and Copper Alloys, Cast and Wrought
- B-6 Die-Cast Metals and Alloys
- B-7 Light Metals and Alloys, Cast and Wrought
- C-1 Cement
- C-4 Clay Pipe

- C-7 Lime
- C-9 Concrete and Concrete Aggregates
- C-11 Gypsum
- C-12 Mortars for Unit Masonry
- C-15 Manufactured Masonry Units
- C-17 Asbestos-Cement Products
- C-21 Ceramic Whitewares and Related Products
- C-23 Sorptive Mineral Materials
- C-24 Joint Sealants
- D-1 Paint, Varnish, Lacquer, and Related Products
- D-2 Petroleum Products and Lubricants
- D-3 Gaseous Fuels
- D-4 Road and Paving Materials
- D-5 Coal and Coke
- D-6 Paper and Paper Products
- D-8 Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses
- D-9 Electrical Insulating Materials
- D-11 Rubber and Rubber-Like Materials
- D-16 Industrial Aromatic Hydrocarbons and Related Materials
- D-17 Naval Stores
- D-18 Soils for Engineering Purposes
- D-19 Industrial Water
- D-20 Plastics
- D-24 Carbon Black
- D-27 Electrical Insulating Liquids and Gases
- E-1 Methods of Testing
- E-2 Emission Spectroscopy
- E-3 Chemical Analysis of Metals
- E-4 Metallography
- E-5 Fire Tests of Materials and Construction
- E-7 Nondestructive Testing
- E-9 Fatigue
- E-10 Radioisotopes and Radiation Effects

- E-12 Appearance
- E-14 Mass Spectrometry
- E-15 Analysis and Testing of Industrial Chemicals
- E-17 Skid Resistance

- Administrative Committee on District Activities
- Administrative Committee on Simulated Service Testing
- Advisory Committee on Corrosion
- Joint Committee on Chemical Analysis by Powder Diffraction Methods
- Joint Committee on Effect of Temperature on the Properties of Metals

African Travelog Feature of Ladies' Program

ONCE AGAIN THE Ladies' Entertainment Committee of the Philadelphia District has planned a unique series of events for the ladies attending the ASTM Annual Meeting.

There will be no registration fee this year. The morning coffee hour will be held on the Lanai Deck adjacent to the new Chalfonte swimming pool. Boat rides along the coast once again await visitors to Atlantic City.

Tuesday evening, an exceptional travelog, "Inside and Around Africa," will be shown by Mr. and Mrs. Drew Betz who traveled the Dark Continent in 1959. Starting at Marrakech, Morocco, the tour moves down through French West Africa and the Ivory Coast. In Dahomey a tribal festival,

Photographers Attention!

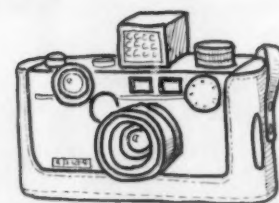
Last Chance to Enter 1960 Photographic Exhibit

PHOTOGRAPHERS who haven't already done so should immediately make plans to submit their best technical photographs for display at the 12th ASTM Technical Photographic Exhibit to be held in Atlantic City, N. J., June 27 to July 1, 1960, in connection with the 63rd Annual Meeting of the Society and the 14th Apparatus Exhibit.

Materials Processing, Testing, and Research will be the theme of the photo show. Photographs featuring apparatus, instruments, processing techniques, testing, standards, and related items are especially desired. Photographs showing unique or unusual applications of materials are welcome, also those featuring the human element.

Any ASTM member or employee of a member company, or university student interested in engineering materials may submit entries in one or more of the following classes:

1. General
 - (a) Black-and-white or monochrome prints



- (b) Color prints
- (c) Color transparencies
2. Photomicrographs
 - (a) Black-and-white prints
 - (b) Color prints
 - (c) Color transparencies
3. Electron micrographs

Closing date for receipt of entries will be Saturday, May 21, 1960.

All members and committee members are being sent an application form with full details regarding rules and regulations. Extra entry forms may be obtained by writing to Society Headquarters, Attention: Photographic Exhibit.

the Grand Tam Tam, is attended. A visit to Dr. Albert Schweitzer's Forest Hospital at Lambarene in French Equatorial Africa follows. Among the other places visited are Kruger and Hlu Hluwe National Parks to view Africa's wild game, Zanzibar, Addis Ababa, and ancient Egypt. The tomb of King Tutankhamen with its 3000-year-old wall paintings, the Great Pyramids, and the Sphinx are viewed in the final pictures of the slide-illus-

trated tour, which is complete with tape-recorded description and background music.

Wednesday, a trip to the Batsto Restoration site of an early iron works, glass factory, and experimental sugar beet farm is planned. Luncheon will be served at Smithville Inn. In the evening the Annual Meeting Dinner and Entertainment will be held followed by dancing in the Carolina Room of the Chalfonte.

Division of Materials Sciences Organization Plan Proposed

You won't be able to "join" the new division, but if you are a member of the Society, you're in it. Such is the proposal of the steering committee to be presented for action at the Annual Meeting. Other points in the proposed organization plan call for an executive committee of ten members (including chairman, vice-chairman, and staff secretary) to be elected by a divisional council. The council (maximum of 100 members) would be composed of appointees from technical committees and members-at-large appointed by the Board of Directors. The council would establish policy for the division.

The division is sponsoring two symposia on Monday, June 27, one on Recent Progress in Materials Science and the other on Nature and Origin of Strength of Materials. Following the Monday afternoon session, an organization meeting for the division will be held. Invitations will be sent to all technical committees to be represented. At this meeting, the proposed scope and by-laws will be presented for adoption and a slate of officers and executive committee members will be presented for election.

William O. Baker to Speak at Materials Sciences Luncheon



William O. Baker, vice-president, research, Bell Telephone Laboratories, Inc., will deliver the address at the Materials Sciences Luncheon to be held on Monday, June 27. Dr. Baker was graduated in 1935 from Washington College, where he was Visitors and Governors Scholar, and received the

Simmons Medal, the Blades Medal, and, in 1957, the honorary degree of Sc.D. He received his Ph.D. in physical chemistry in 1938 from Princeton Univ., where he was Harvard Fellow and Proctor Fellow. Since 1939 he has done research at Bell Telephone Laboratories in the fields of macromolecules, the basic elements of plastic, fibers, natural and synthetic rubbers, and of the tissue of growing plants and animals.

During World War II, his work leading to the discovery of a new kind of synthetic polymer molecule called microgel was identified by the War Production Board as "ahead of all other fundamental work carried out in the synthetic rubber program." His studies of the structure of synthetic plastics, especially of polyamides, revealed new ways to apply purely synthetic materials to communications systems.

More recently, Dr. Baker has been collaborating in the study of the movement of electrons in and through organic substances. He has been granted some

ten patents on subjects involving high polymers, including a recent one on a method of increasing the strength of solid fuels such as are used in rocket propellants.

Dr. Baker is a member of the President's Board of Consultants on Foreign Intelligence Activities, chairman of the National Science Information Council, chairman of an advisory group in the Department of Defense, a member of the Committee on Industrial Chemistry of the National Research Council, and a past member of the President's Science Advisory Committee. He has also served with the Office of Scientific Research and Development, the Panel on Physical Chemistry for the Office of Naval Research, and the Advisory Panel for the Research and Development Section of the Quartermaster Corps.

He is a trustee of the Mellon Inst. and serves on Visiting Committees for Chemistry of Harvard, Princeton, New York, and Rutgers universities. He has been visiting lecturer at Polytechnic Institute of Brooklyn, Northwestern, Princeton, Western Reserve, and other universities. He is a member and past-councilor of the American Chemical Society and a member of the American Physical Society. He serves on the ASTM Administrative Committee for Research, on the Editorial Board of the *Journal of Polymer Science*, and the Advisory Board of *Chemical and Engineering News*. He is a member of the Directors of Industrial Research, Industrial Research Inst., Sigma Xi, Omicron Delta Kappa, and other professional groups.

Papers to Appear in Future Issues of the ASTM Bulletin

- A Study of Rheological Testing of Elastomers at Low Temperatures, Part II*—L. Boor, Military Clothing and Textile Supply Agency, U. S. Army; Max Hanok, New York Naval Shipyard; F. S. Conant, Firestone Tire and Rubber Co.; and W. E. Scoville, Jr., Boston Woven Hose and Rubber Co.
- Measurement of the Brittleness Temperature of Polyethylene*—A. M. Birks and A. Rudin, Canadian Industries Ltd.
- Design Criteria for 6 Al-4 V Titanium Alloy at Room and Elevated Temperatures*—J. K. Childs and M. M. Lemcoe, Southwest Research Inst.
- A Vicat-Type Penetration Tester for Evaluating Hardness and Elastic Recovery in Polymeric Materials*—K. W. Gardiner, Consolidated Electrodynamics Corp.; and T. F. Jordan and F. W. Adams, Continental Can Co.
- A Burst Test for High-Strength Fabrics*—K. F. Plitt and L. A. Dunlap, National Bureau of Standards
- Measurements of Human Reaction to Hardness of Floor Covering*—Rolf Schjodt, Norwegian Building Research Inst.
- Measurement of Surface Moisture and Sulfur Dioxide Activity at Corrosion Sites*—P. J. Sereda, National Research Council of Canada
- An Improved Microhardness Tester for High-Temperature Use*—J. H. Westbrook, General Electric Co.
- An Improved Method for the Determination of the Normal Consistency of Plasters*—R. A. Kuntze, Ontario Research Foundation

1960 Marburg Lecture—Solar Energy

The Lecture . . .

The abundance and limitations of solar energy will be discussed, together with a review of solar energy research, emphasizing particularly the new materials that are necessary in the successful application of solar energy. The research review will include the subjects of heating, cooling, distillation of salt water, solar engines, photoelectricity, thermal electricity, and photochemistry. New materials to be discussed will include: (1) plastics for reflectors and covers for solar collectors; (2) silicon in solar cells; (3) solid-state devices for thermoelectric and thermionic energy converters; (4) refrigerant systems for possible application in solar cooling cycles; and (5) selective coatings for attaining high efficiency energy absorbers.

The Lecturer . . .

Dr. Daniels is Professor Emeritus of the University of Wisconsin and vice-president of the National Academy of Sciences. A native of Minneapolis, Minn., he received his bachelor's and master's degrees at the University of Minnesota in 1910 and 1911, respectively. His doctorate in chemistry was earned at Harvard in 1914. He taught

at Worcester Polytechnic Inst., did research in fixed nitrogen at the U. S. Nitrogen Research Laboratory in Washington, 1919-1920. Since 1920, he has been a teacher, researcher, writer, and from 1952 to 1959 chairman of the



FARRINGTON DANIELS, professor emeritus of the University of Wisconsin, will present the 1960 Edgar Marburg Lecture on Wednesday afternoon, June 29. This annual lecture is a memorial to the first secretary of ASTM and was established to emphasize the importance of furthering the knowledge of properties and testing of engineering materials.

Chemistry Department at the University of Wisconsin, where he is now engaged in research on the utilization of solar energy at the Engineering Experiment Station.

He was lecturer at Stanford University in 1930, Baker nonresident lecturer at Cornell University in 1935, director of the metallurgical laboratory of the University of Chicago for atomic energy 1945-1946, and chairman of the Board of Governors of the Argonne National Laboratory 1946-1948. Currently he is serving on a committee on International Exchange of Persons, and a committee of the National Aeronautics and Space Administration on Chemical Energy Sources.

Honorary doctor of science degrees have been awarded him by the universities of Minnesota, Rhode Island, and Dakar. He is a past-president of the American Chemical Society and of the Geochemical Society, and past-vice-president for chemistry of the American Association for the Advancement of Science. He also holds membership in the American Philosophical Society, the American Academy of Arts and Sciences; and holds the Minnesota Outstanding Achievement Award and the American Chemical Society J. F. Norris Award, Willard Gibbs Medal, and the Priestley Medal.

1960 Gillett Lecture—Nuclear Fuel Elements

The Lecture . . .

Probably one of the most difficult problems facing the designers of nuclear reactors is that of standardization of fuel elements. Dr. Dalzell will outline the scientific problems and the engineering and economic considerations that are important in this developing industry. Research and development methods and observations will be discussed. He will summarize the implication of all factors, including opportunities and prospects for standardization. His lecture will be prepared for those whose interests range from materials science to applied engineering.

The Lecturer . . .

Dr. Dalzell is assistant to the director of the Division of Reactor Development, United States Atomic Energy Commission, Washington, D. C. He is a native of Beaumont, Tex., but received most of his education in Baltimore, Md., graduating from Johns Hopkins University in 1927. He completed, by 1929, the work for the degrees of M.S. and Sc.D. in metallurgy at Harvard. From then until 1950, most



R. CARSON DALZELL will present the 8th Gillett Memorial Lecture on Tuesday, June 28, at 5 p.m. This lecture, jointly sponsored by the ASTM and Battelle Memorial Institute, commemorates Horace W. Gillett, first director of Battelle and one of this country's leading metallurgists. Each year it covers a subject pertaining to the development, testing, evaluation, and application of metals.

of his experience was with the American Smelting and Refining Co. and Revere Copper and Brass, Inc., in applied research, development engineering, application engineering, plant control, and general management.

He joined the staff of the U. S. Atomic Energy Commission in 1950 to plan and administer the general materials research and development program of the Division of Reactor Development. Appointed Chief of the Engineering Development Branch in 1956, he was placed in charge of all general development work in the division. Now assistant to the director of reactor development, he has primary responsibility for technical coordination of the military and maritime reactor programs.

Dr. Dalzell is the AEC representative on the Nuclear Standards Board of the American Standards Assn. and is a member of the U. S. delegation to meetings of the International Standards Organization's Nuclear Committee. Currently, he is chairman of the ASME's Nuclear Engineering Division and is an active member of nuclear and metallurgical committees of ASME, ASM, and ASTM.

Exhibit of Testing and Scientific Apparatus and Laboratory Supplies

Leading Manufacturers Feature New Apparatus Related to ASTM Testing and Research

THE SOCIETY's 14th Exhibit of Testing and Scientific Apparatus and Laboratory Supplies will be an important feature of the Annual Meeting. The latest in research and testing apparatus will be displayed by the country's leading manufacturers. Hundreds of items ranging from small, hand-manipulated instruments and electronic control devices through high-temperature ovens and heating elements to giant universal testing machines will be exhibited. Displays will be in the English Lounge and the Vernon Room of Haddon Hall near the registration area. Exhibit hours are as follows:

Monday 12:00 noon to 5:45 p.m.
and 7:15 to 9:30 p.m.

Tuesday 11:00 a.m. to 5:45 p.m.
and 7:15 to 9:30 p.m.

Wednesday 9:00 a.m. to 5:30 p.m.
Thursday 11:00 a.m. to 5:45 p.m.
and 7:15 to 9:30 p.m.

Friday 9:00 a.m. to 1:00 p.m.

A brief description and photographs of the various kinds of apparatus that will be on display appear on the following pages.

Ace Glass, Inc.

Booth No. 29

Featured will be the new Ace plastic coating which forms a protective film around glass. This film will normally contain both the glass particles and the dangerous chemicals should the glass break during hazardous experiments. It is particularly valuable for coating vacuum systems, dewars, and joints, and will also aid in making vacuum systems more fool-proof against losing vacuum during operation. It can also be used to give glass a greater degree of resistance to breakage from mechanical shock. Any desired degree of thickness can be obtained by applying the required number of coats.

American Instrument Co.

Booth No. 22

On display will be the research gas chromatograph, with high-temperature columns, utilizing various detectors and liquid injection systems; AMINCO-Thermo-Grav, an automatic recording vacuum thermo-balance; direct-reading hygrometer indicator; AMINCO-Winslow porosimeter, for determination of porosity using mercury intrusion method; ASTM plastics deflection tester with spool and adapters for Vicat testing of polyethylene-like samples; Yezley oscillograph for evaluat-

ing properties such as resilience and shear of rubber and similar materials according to ASTM Methods D 945.

Atlas Electric Devices Co.

Booth No. 21

On display will be the latest model Weather-Ometer equipped with automatic control of relative humidity, specimen temperature, etc.

AVCO Corp.

Booths 48 & 49

A shock test machine specifically designed for testing ballistic missile components will be featured in the Avco booth. It is claimed to be the first shock test machine specifically developed to meet the rigid specifications of WS-107A-2 (Ballistic Missile Div., U. S. Air Force) environmental test requirements for airborne electronic equipment. It is designed to produce and precisely reproduce a sawtooth wave shock pattern of more than 100 g over the shock response spectrum in 80 to more than 1000 cps and can attain shocks in excess of 1500 g as well as a variety of other pulses.

Baldwin-Lima-Hamilton Corp.

Booths 64 & 65

A 10,000-lb capacity Mark G universal testing machine will be featured in the Baldwin display along with a Bell Laboratories impact testing machine with specimen-in-head impact test adapters, and the Model TP-1 torsional pendulum for measuring crystallinity of Teflon resins.

Bausch & Lomb Optical Co.

Booth No. 63

On display will be the new Bausch & Lomb Spectronic 505, a double-beam, double-grating, recording spectrophotometer. Some of its features include a chart speed which automatically adjusts to curve complexity, a double-grating monochromator, three linear wave-length scales, six photometric range values, built-in mercury calibration lamp, three external high-intensity light sources, and double-beam splitter. Six different rates of scan through the spectrum are easily selected or changed by a knob on the instrument panel. A reflectance attachment is also available.

Beckman Instruments, Inc.

Booth No. 24

A new double-beam ultraviolet spectrophotometer and a new potentiometric laboratory recorder will highlight this display. The DB® spectrophotometer offers double-beam versatility for rapid, accurate analyses in the 200 to 770 mμ wavelength range. With the accessory

Beckman potentiometric laboratory recorder, the instrument adapts for true percent transmittance recording, differential analyses, and reaction rate studies; the recorder monitors direct-current signals in the 10 to 100 mv range. The compact recorder also can be used with other laboratory instruments such as pH meters. Infrared spectrophotometers and gas chromatographs also will be featured in the exhibit.

James G. Biddle Co.

Booth No. 58

The James G. Biddle Co. will exhibit its complete line of dielectric test equipment together with several models of Megger insulation testers in the high-voltage class. A demonstration unit of the Biddle corona test equipment will be shown operating with a variety of test samples. Other equipment to be displayed: the Ducter low-resistance ohmmeter and rectifier-operated Megger instruments; Jagabi wire-wound and carbon-pile rheostats; Tinsley coating thickness gage; the Megger floor conductivity test kit, and Apiezon high-vacuum oils, waxes, and greases.

J. Bishop & Co.

Booth No. 51

On exhibit will be the company's complete line of standard platinum laboratory ware including precious-metal crucibles, dishes, tongs, tweezers, cones, pans, sheet, foil, gauze, microapparatus and some special laboratory ware to customer specification. In addition Bishop will exhibit its complete line of specially packaged thermocouple and resistance wires including clads and composites. One section of the display will be devoted to small-diameter (0.008 to 1 in. OD) stainless-steel, nickel, nickel-alloy, and special and exotic type tubing and tubular products.

C. W. Brabender Instruments, Inc.

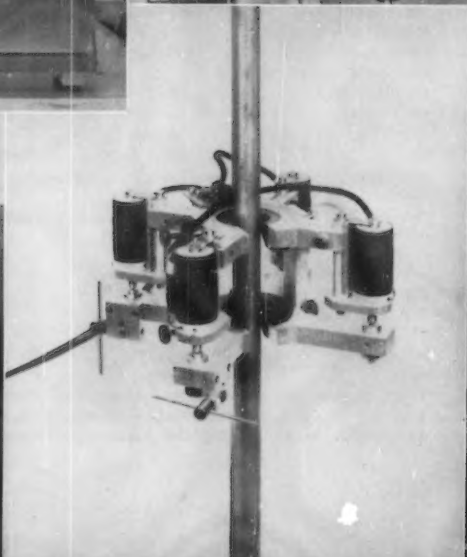
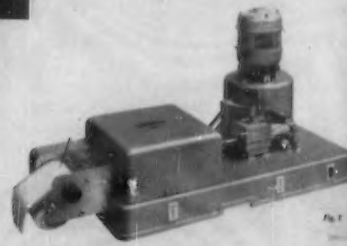
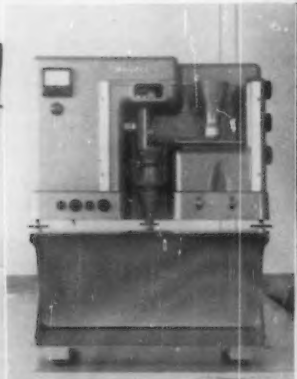
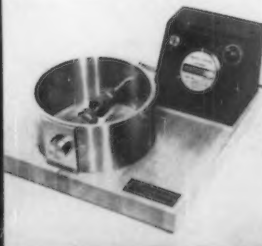
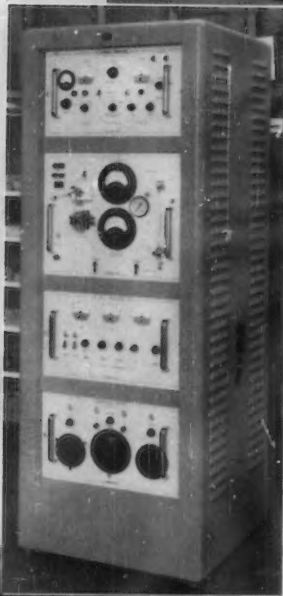
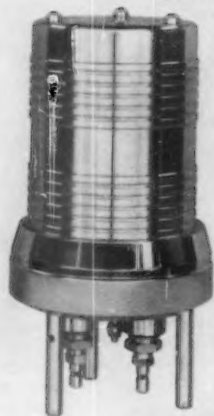
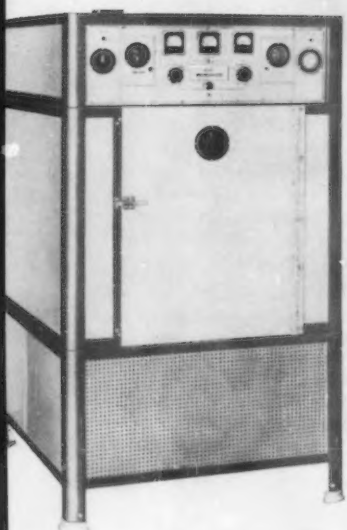
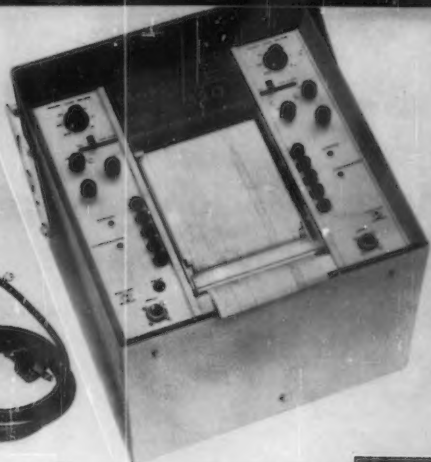
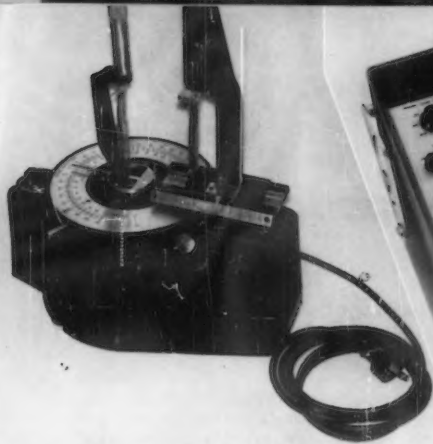
Booth No. 4

Featured in this booth will be the C. W. Brabender Plastograph, now designed for testing of chemical-process materials, including all high polymers. It evaluates the processibility of polymers, elastomers, pastes, and slurries. Its various measuring heads can simulate process conditions of shear force and rate of shear. Wide instrument adjustment is possible—up to 650 F and 3000 sec⁻¹ shear rate.

Branson Instruments, Inc.

Booth No. 5

Branson Instruments will display its SONORAY ultrasonic flaw detector and AUDIGAGE and VIDIGAGE ultrasonic thickness testers. The SONORAY provides high



precision and flexibility in an extremely portable instrument, equally at home in the metallurgical laboratory or the manufacturing plant. The VIDIGAGE and AUDIGAGE thickness testers provide extreme accuracy in thickness measurements from one side only. The VIDIGAGE can be adapted for recording or signaling when thickness exceeds preset limits.

The Budd Co.

Booths 35 to 38

The Instruments Div., The Budd Co., will display Tatnall MetalFilm strain gages, PhotoStress, optical strain measuring equipment, load cells, and Tatnall-Krouse fatigue equipment. In addition, a new line of eddy-current nondestructive test equipment and Recordflux magnetic-particle inspection material will be featured. Also displayed will be the standard line of gamma radiography devices.

Buehler Ltd.

Booths 59 & 60

Sections of metal to be studied under the microscope to reveal their structure must be ground flat then polished and etched. In many cases this can now be accomplished by electrolytic action rather than abrasive action. A limited surface of the sample is brought in contact with the electrolyte and is made the anode. Electrical current passing between the anode and the cathode removes metal from the anode (the opposite of electroplating). With properly controlled conditions a mirrorlike surface results from which all surface distorted metal has been removed. The Buehler electrolytic polisher is designed to provide the required controlled conditions in a practical laboratory apparatus.

Circo Ultrasonic Corp.

Booth No. 61

Featured will be the Circo Model CM 100 ultrasonic materials tester, a precision-engineered instrument used for non-destructive inspection of material which can support ultrasonic waves. Its uses include flaw detection, either surface or internal; thickness measurement from one side; and determination of physical and structural properties. The unit is portable, designed for in-plant use, simple and economical to operate, and can use any common plant power supply.

Cosa Corp.

Booth No. 56

A Universal Pulsator "PUV" vertical fatigue testing machine, recently added to the Schenck line of testers, will be featured in the booth of the Cosa Corp., distributors of this equipment. The new series of four sizes covers a load range from 0.6 to 20 tons and a frequency range from 600 to 10,000 cpm. The extremely large stroke of the machines enables them to test very soft materials with low frequency and

rigid parts with high frequency. A series of standard accessories permits easy conversion for bending, torsion, or other tests. Various gripping devices, heating and freezing chambers, and program control attachments are also available.

Coulter Industrial Sales Co.

Booth No. 34

Coulter Industrial Sales Co. will demonstrate the Coulter counter, a new approach to particle-size analysis in the subsieve and low-sieve ranges (0.5 to 250 μ). All types of materials, such as dusts, pigments, ceramics, foods, chemicals, cement, emulsions, liquid contaminants, metal powders, and abrasives may be analyzed rapidly in production, quality control, and research applications. A complete size distribution analysis is obtained typically in a few minutes, using a new measurement principle. Number and size of particles are measured through high-speed electronic sensing of individual particle volumes, without dependence on particle shape, density, or other factors.

Custom Scientific Instruments, Inc.

Booth No. 6

CSI will feature two units. The first is the Gregg tension ring, developed to test high-strength steel parts for static fatigue failure. This development was required due to the large number of specimens that must be tested and the fact that use of universal testing machine was impractical because of the extended time each specimen is under test. The second unit is the Pittsburgh Corning thermal conductivity probe unit which is claimed to furnish means and methods having the precision of the guarded hot plate while avoiding most of its problems. Shorter testing time per sample and low initial cost are some of the advantages.

The Electric Hotpack Co., Inc.

Booth No. 10

On display will be: (1) A new vacuum oven with a range up to 300 \pm 0.5 C with a pull-down to 1 μ . Controls include vacuum gage, wattage selector switch, thermometer. (2) Hot-cold test chamber, 100 to 400 \pm 1.0 F. This is a table-top model with lift-out drawer, high-velocity blower, carbon dioxide injection. Controls include indicating-controlling thermostat, hi-lo wattage switch. (3) Constant temperature bath 0 to 60 C (refrigerated), 30 to 125 \pm 0.2 C, main and auxiliary heaters, motor stirrer, adjustable thermostat, stainless-steel construction. (4) Electric furnace, ambient to 1900 F in 25 min, with indicating pyrometer, percentage timer, new KT insulation, portable, and having steel construction.

Fisher Scientific Co.

Booth No. 26

Fisher Scientific will show its zone refiner, which automatically purifies chemi-

cals melting from 50 to 300 C; its ASTM colorimeter for Method D 1500; Duo-Spectranal, a unique spectroscopy for high-speed qualitative and semiquantitative analysis; its direct-reading gas partitioner Model 25 for Orsat gas analyses in 10 min; and its Fisher-Gulf partitioner Model 300, an automatic gas chromatograph that analyzes mixtures of compounds that boil up to 425 C.

Gardner Laboratory, Inc.

Booths 52 & 53

Featured will be the new Gardner Model AC-2a, Series 200, high-sensitivity automatic color-difference meter for laboratory and production use in measuring the color differences of solids, powders, and liquids. This is a high-precision, direct-reading instrument for speedy measurement of minute color differences in either solid or liquid materials. Also displayed will be a selected new line of scientific instruments, laboratory apparatus, and standard tapered glassware, including the Sartorius Selecta Balance and other analytical measuring instruments.

William J. Hacker & Co., Inc.

Booths 27 & 28

The following new equipment will be shown in operation: a fully automatic electronic tensile tester for fibers, yarn, etc., with load measurements of from 5 to 20,000 g; an apparatus for electromechanical polishing of metallographic samples difficult to prepare by other means; the Nomarski interference contrast equipment and polarizing interferometer for the optical assessment of the surface finish of metals. On display also will be the Reichert metallographs and other metallurgical microscopes, and the Struers metallographic specimen preparation apparatus including pregrinders, diamond and electropolishers, and the Zwick line of physical testing machines for rubber and plastics.

Hunter Associates Laboratory, Inc.

Booth No. 11

The mirror quality of metallic finishes and the gloss of automobile enamels and other high-gloss paints can be measured with the new distinctness-of-image glossmeter to be featured in the Hunterlab exhibit. Included in the exhibit will be a digital dial D25 color difference meter with direct-reading color difference attachment, fluorescent sensitive D40 reflectometer for whiteness and D16 multipurpose glossmeter which will make accurate measurements of gloss at 20, 45, 60, and 75 deg.

Hunter Spring Co.

Booth No. 42

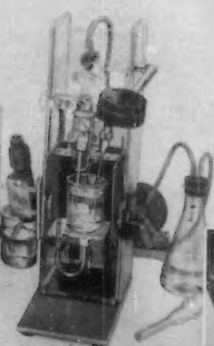
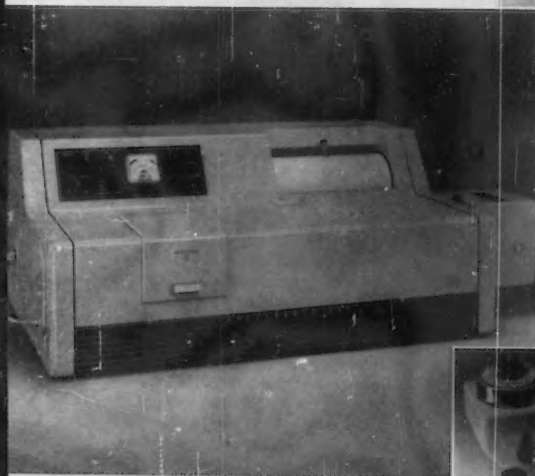
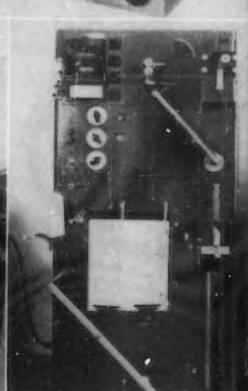
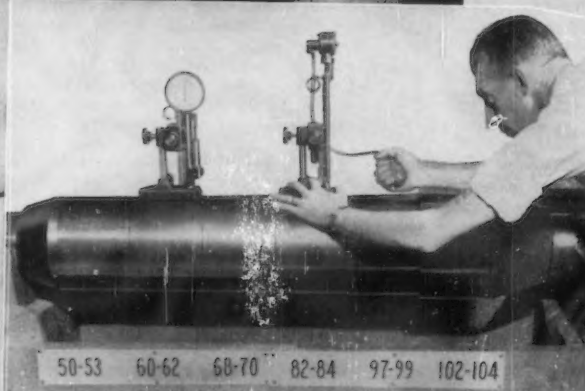
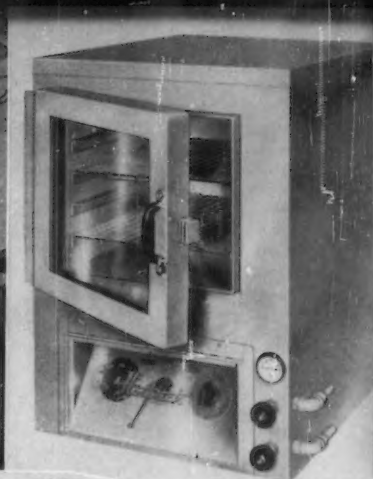
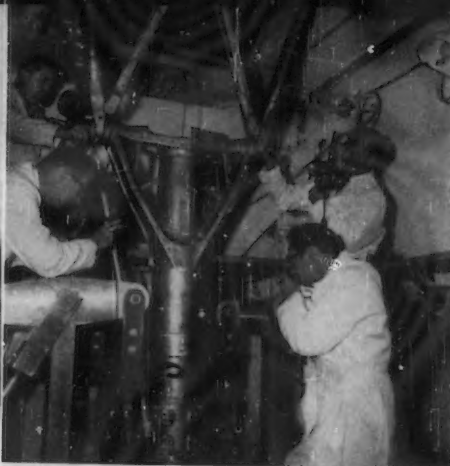
Unusual compactness and simplicity of operation characterize a portable tensile tester to be exhibited in the Hunter booth. The unit is designed for bench-top operation by compressed air for destructive and nondestructive quality control tests in ranges of 0 to 500 lb, with laboratory accuracy, at the production site. Also shown will be Hunter's complete line of mechanical force gages for measuring push and pull forces in design and test work on materials, assemblies, bonds, and joints.

First row, left to right: Carson-Worthington stiffness tester; Sanborn portable recorder, DB[®] spectrophotometer.

Second row, left to right: Weather-Ometer; inverted oxygen bomb; gas chromatograph; capillary melting point apparatus.

Third row, left to right: Gregg tension ring; DWA filling balance; plastic coating for laboratory glassware; Curometer.

Fourth row, left to right: corona test set; axial alignment checker; digital system—control console, Monroe datalog printer, test assembly.



Instron Engineering Corp.

Booths 16 to 18

Visitors will see the all-new Instron digital readout system for high-speed materials testing. In 15 sec this equipment can test a specimen and print out in digital form the values of total elongation, maximum load, breaking load, and energy to break. Test results are instantly available, without need for any calculations. No time is spent interpreting charts. Specimen after specimen can be run as rapidly as necessary to provide on-the-spot quality control checks.

Laboratory Equipment Corp.

Booth No. 57

Laboratory Equipment Corp. will demonstrate the recently announced LECO hot-extraction hydrogen analyzer. This instrument combines speed and simplicity of operation with great accuracy to meet the need for determination of hydrogen in metals. Also in operation will be the high-frequency induction furnace with carbon and sulfur analyzers. The conductometric carbon analyzer for samples of low carbon content and an automatic determinator for the volatile material in coal and coke will be shown. A complete line of special ceramic ware for high-temperature use up to 2700 C will round out the display of advanced apparatus for chemical analysis of metals.

Leeds & Northrup Co.

Booths 1 & 2

Four portable potentiometers, a guarded null detector and two galvanometers will be shown, from the company's newly-developed "E" line. Potentiometers feature the central window readout, to promote rapid, accurate reading, and are smaller and lighter than the L&N instruments they replace. Ranges are in volts, millivolts, and temperature. The guarded null detector is used with either guarded or unguarded potentiometers and bridges. It has four ranges and a noise level of less than 0.1 μ v. The pointer galvanometer and reflecting galvanometer are rugged, portable instruments for laboratory or plant. Sensitivities range from 1 to 0.01 μ a per mm scale division and may be changed at will.

Mettler Instrument Corp.

Booth No. 14

Mettler Instrument Corp. will feature the all-new type R5 recording balance and type DWA filling balance. The recording balance features photoelectric coupling between the balance and recording chart and the 100-mm effective recording width. It has a variety of recording ranges and sensitivities. The type DWA filling and batching balance is designed to permit automatic or semiautomatic weighing out of accurate quantities of powdery or granulated materials and may be set up

for stream analysis. Also exhibited will be a type K precision scale for fast, accurate weighings and type H multipurpose balances.

Newage Industries, Inc.

Booth No. 32

Newage Industries will have on display its new microhardness tester which produces direct readings corresponding to Vickers in 15 sec. This instrument does not use the conventional optical view system; all tests are read directly on a large dial. The tester can be carried from department to department without damage or adjustment. A patented loading mechanism is designed to be frictionless and free from side thrust. Also on display will be the Newage portable metal hardness tester.

Olsen Scientific Instruments, Inc.

Booths 67 & 68

Featured in this booth will be the "S.M." automatic polisher, which can be attached to present 8-, 10-, or 12-in. wheels now in the user's laboratory. Specimen holders for 1-, 1½- and 1½-in. mounts are available, as are special holders for irregularly shaped specimens. The machine can be left while three specimens are being polished automatically at one time, a time-saving feature.

Tinius Olsen Testing Machine Co.

Booths 19 & 20

Featured will be a new low-capacity Olsen testing machine with related recording instrumentation, usable for metals, plastics, and small structural parts. Also included will be a new plastic tension-impact machine, specimen-in-head type, originated in conjunction with the work of Committee D-20 on Plastics. A new portable extensometer calibrator will be demonstrated along with several types of soil testing machines. Of particular interest to those in the plastics field will be a monofilament extruder.

Parr Instrument Co.

Booth No. 41

A complete assortment of oxygen and sodium peroxide bombs for calorimetry and combustion tests will be featured in the Parr exhibit. This will include a new self-sealing oxygen bomb that can be operated in either the conventional or inverted position, and which can be fully lined with platinum; an adiabatic calorimeter; a new semimicro oxygen bomb calorimeter; pressure reaction apparatus with 1- and 2-liter stainless-steel bombs; and various small bombs for pressure test purposes. The Parr melting point apparatus will also be on display.

Plas-Tech Equipment Corp.

Booth No. 15

The Plastechon universal tester, new table and floor model versions capable of

speeds from the static to the dynamic loading range, will be demonstrated. Representative dart-drop equipment, both instrumented and uninstrumented, will also be on display. An exhibit of various Plas-Tech activities in materials research and equipment manufacture will also be available.

Riehle Testing Machine Div., American Machine and Metals, Inc.

Booths 43 & 44

On display will be the Riehle Model F-400 Electro-Balanced load indicating unit with complete instrumentation, including stress-strain recorder, strain-rate indicator, load-rate indicator, stress computer, automatic strain-rate and load-rate controller, and load cell attachment; strain-time recorder; load-time recorder; X-Y recorder; extensometers; extensometer and recorder calibrator; and axial alignment checker.

The I. E. Robinson Co.

Booth No. 50

The I. E. Robinson Co. display will feature new developments in strain gages, displacement transducers, and complete electronic instrument systems for observing and recording data from various types of sensing elements. It will include: B-L-H Strainline photoelastic strain gages and strain compasses; the Baldwin SR-4 universally temperature-compensated strain gage, Type FNH, which can be used over a broad temperature range and on a wide variety of materials; and Sanborn portable recorders, including a dual-channel unit and the new single-channel units with straight direct current and amplification and with a built-in corner amplifier.

August Sauter of New York, Inc.

Booth No. 39

Sauter will feature balances and scales suitable for micro to macro weighings. The TOPPAN, a fully automatic balance featuring front and rear projection reading and operating on the principle of substitution weighing, is the newest addition to the Sauter line. Other items to be exhibited are a single-pan analytical balance of extremely modern design and employing the principle of substitution weighing; the Sauter Ultra-Matic micro balance and the Inframatic used for spectroscopy and infrared moisture determinations; and a fully automatic bench-type dial scale along with analytical weights and balance accessories.

Scott Testers, Inc.

Booths 7 & 8

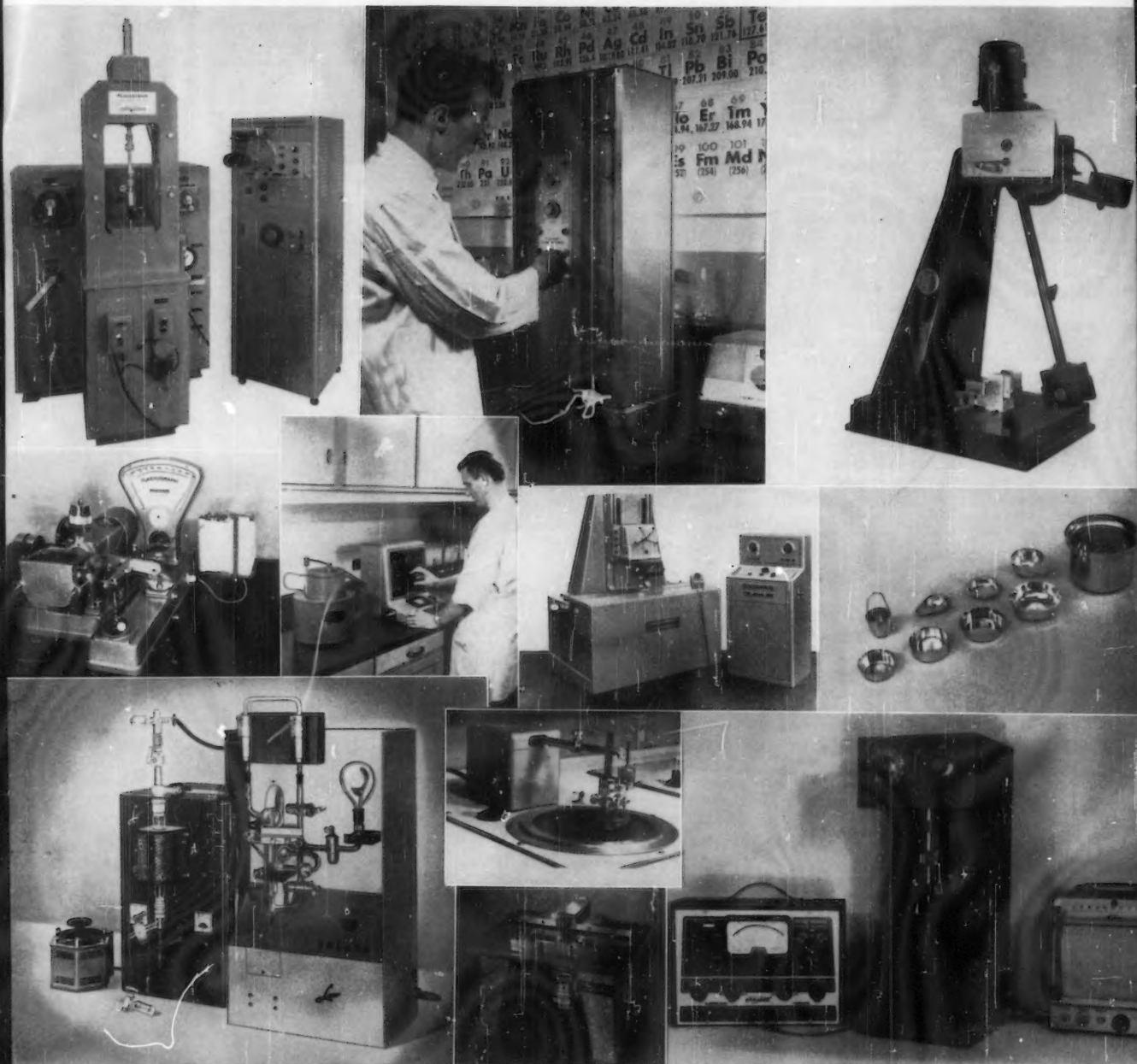
Automatic, fingertip controls will be featured on the three testers displayed by Scott Testers, Inc. The Model CRE constant-rate-of-extension tensile tester has an ultra-precise electronic weighing system and provides an infinite variety of crosshead speeds, a wide selection of interchangeable test capacities, and instant response to rapidly fluctuating loads. Of special interest to rubber technologists will be the Model CRE pipping circuit which permits manually-controlled representation of visually-observed specimen elongation. Demonstrations of the Model STI Mooney viscometer will show how fingertip, pneumatic-powered controls close dies

Top row, left to right: microhardness tester; B-58 Hustler landing gear undergoing optical stress analysis with a PhotoStress LF/Z meter; vacuum oven.

Second row, left to right: automatic balance; Scleroscope; automatic electronic tensile tester.

Third row, left to right: recording spectrophotometer; tensile tester; ultrasonic materials tester.

Fourth row, left to right: distinctness of image gloss meter; microhardness tester (insert); counter for particle-size analysis; constant rate of extension tester (above); color difference meter.



Top row, left to right: high-speed universal tester; zone refiner; remote-controlled impact tester.

Second row, left to right: Plastograph; electrolytic polisher; universal pulsator vertical fatigue testing machine; platinum laboratory ware.

Third row, left to right: hydrogen analyzer; automatic polisher (above); TensilkuT (below), Vicateter.

uniformly, and eliminate physical effort or tedious adjustments. The Scott brittle point tester (Model E) for rubber and other elastomers will be displayed with a velocity calibration kit.

Service Diamond Tool Co.
Booth No. 40

Service Diamond Tool Co. will display its line of hardness testers including

standard Rockwell testers, superficial testers, motorized units, and microhardness and portable hardness testers. Accessories will also be shown.

The Shore Instrument & Mfg. Co., Inc.
Booth No. 62

Featured will be the Scleroscope for testing the hardness of metals. It will be demonstrated on a forged steel roll, an ap-

plication to which it is well adapted because it does not mar the roll. All models of Shore Durometers for testing the hardness of rubber and plastics will be displayed, as well as the Duocalibrator, which is designed for field use in calibrating and verifying the accuracy of the Durometers.

Sieburg Industries, Inc.
Booth No. 55

Featured will be TensilkuT high-speed milling equipment for rapid and accurate machining of physical test specimens from foil, film, sheet, and plate metals and non-metals. This technique allows light, 0.0005-in. foil to be machined with edges

free of burrs or cold working, and yet there is the capacity to machine $\frac{1}{8}$ -in. plate with configuration accuracies duplicated within 0.0005 in. A wide range of master templates will be included for machining tensile, fatigue, creep, compression, tensile-impact, or flexure specimens from soft film plastics to abrasive glass laminates, or stainless steel foil to steel plate.

Testing Machines, Inc.

Booths 30 & 31

Featured in the TMI display will be three major items: the Wallace Rapid Plastimeter to measure plasticity of unvulcanized rubbers in the factory; the Wallace-Shawbury Curometer which records the cure characteristics of rubber while vulcanization takes place; and the TMI remote controlled safety impact tester for metals, particularly convenient for testing at subnormal or supernormal temperatures; it makes either the Izod, Charpy, or tension impact test.

Arthur H. Thomas Co.

Booth No. 23

On display will be the Thomas-Hoover capillary melting point apparatus, high-

frequency induction furnaces, oil centrifuges, and quick-weighing balances. Also exhibited will be the Immerex apparatus, Tempunit constant-temperature device, Schoniger micro combustion apparatus, as well as various other items.

Thwing-Albert Instrument Co.

Booths 12 & 13

A number of new instruments developed for the paper, plastic, rubber, and printing ink industries will be shown: three new attachments for the Elmendorf tearing tester—torsion attachment for torsion tearing of materials, toughness attachment for high-speed tensile or toughness tests, and the Spencer impact attachment for testing and impact strength of plastic films; the new Vicatmeter for hardness and recovery testing of plastisol materials; the Fotosize penetration tester, an electronic instrument for measuring the penetrability of paper; the Albert torsion tester; the Inkometer recorder and direct-reading attachment; and the new textile Elmendorf tearing tester.

United States Testing Co.

Booths 46 & 47

The Product Division of the United

States Testing Co. will exhibit its standard cataloged line of pretested and approved laboratory apparatus and instruments, including four new items. A precision, low-cost, six-tube viscometer bath, stiffness tester for paper, and moisture tester will be shown along with an extensive line of tested ASTM thermometers and critical laboratory glassware. A highlight of the display will be an operating model of the newly introduced precision magnetic separator, which, by detection of trace amounts of magnetic materials in products such as tablets, can select acceptable products on a controlled basis.

Wilson Mechanical Instrument Div.

Booth No. 3

The featured product in the Wilson Mechanical Instrument Div. booth will be the Model LL Tukon microhardness tester. This semiautomatic tester is designed to expedite testing cutting-tool carbide tips, watch springs, paints, plastics, etc. Simple in operation, an important asset of this tester is the reduction of operator fatigue. Several other models of Wilson hardness testers will also be shown.

International Congress on Plastics Processing

AMSTERDAM AND Utrecht, The Netherlands, will be host cities next fall to an international congress and an exhibition on plastics. Theme of the congress, to be held October 17-19 at Amsterdam, will be the technology of plastics processing, with papers on extrusion, calendering, molding, thermoforming, and manufacture of reinforced plastics and foams. The plastics exhibition is to be held in Utrecht October 19-26. Sponsors for the congress and exhibition are The Netherlands Society for Materials, Royal Institute of Engineers, and Royal Netherlands Chemical Assn.

Papers are being invited, and inquiries should be sent to: The Secretariat, c/o N. V. 't Raedthuys, Tesselschadestraat 5, Amsterdam-W, Holland, The Netherlands.

D-16 Member Represents ASA At ISO/TC 78 Paris Meeting

A MEMBER OF Committee D-16 on Industrial Aromatic Hydrocarbons and Related Materials, acting as a representative for the ASA, attended the third plenary meeting of ISO/TC 78 in Paris, December 7-9, 1959. The British Standards Institution holds the Secretariat for TC 78. This was the first meeting at which the United States was acting as a participating member in ISO/TC 78 on Aromatic Hydrocarbons.

At the present time there are three working groups within this committee: No. 1 on Sampling, No. 2 on Total

Sulfur, and No. 3 on Density and Specific Gravity. Two more working groups are being organized to cover nomenclature and distillation methods.

Working Group 1 on Sampling presented two methods for consideration: a Draft Method for Sampling Liquid Aromatic Hydrocarbons in Bulk Storage and a Draft Method for Sampling of Lower-Boiling Aromatic Hydrocarbons (this covers sampling in various types of containers). These sampling procedures are based largely on ASTM Method D 270; however, certain difficulties with the use of this method for international use require that some modifications to the ASTM Method be made.

Working Group 2 on Specific Gravity and Density is developing four proposals covering:

1. The Interconversion of Densities and Specific Gravities for Specification Purposes,
2. The Interconversion of Densities and Specific Gravities in Various Technical Specifications for Benzene Products,
3. Conversion Tables for Specific Gravity of Pure Benzene and Toluene from 15 deg/15 deg Cent to a Higher Temperature Suitable for Tropical Use, and
4. Determination of Relative Density of Different Aromatic Hydrocarbons Between 10 and 35 C, and Density to Volume Conversion at 20 C.

It was decided by the working group that the density correction tables that would eventually be adopted by ISO should be based on the data of API Research Project 44 (also the basis for Method D 1555).

The British delegation is strongly in favor of using 15.56 C as the reference temperature for benzene. At the present time the French use 15.5 C, but wish the tables to be based on 20 C in order to comply with a general ISO recommendation which states that liquid measure should be based on 20 C.

The Russian delegation, although not present at this meeting, is understood to favor 20 C. India favors a temperature higher than 20 C.

On the basis of ASTM D 1555, the USA delegation stated that US industry prefers a reference temperature of 15.56 C.

Working Group 3 on Sulfur reviewed the Rhône-Poulenc Method for Determination of Total Sulfur in Benzene. This method is used to cover three ranges of sulfur concentration: greater than 50 ppm, 15 to 60 ppm, and on the order of 1 ppm.

The Plenary Sessions reviewed a method developed for the new Working Group 5 on Distillation and the following proposals:

The determination of crystallization point method met general agreement. This method agrees almost exactly with ASTM Method D 852.

The proposals for determination of hydrogen sulfide, mercaptans, and corrosive sulfur presented were considered as being straightforward methods by the American delegation.

Specifications for benzene and benzols, toluenes and toluoles, and mixed xylenes were discussed at the plenary sessions. The American delegation entered into discussion of many points such as clarity of product, crystallizing point, flash point, benzene as a toxic hazard in toluenes, and so on.

Provisional Program

Sixty-third Annual Meeting

American Society for Testing Materials

Atlantic City, N. J.

June 27–July 1, 1960

MONDAY, June 27	TUESDAY, June 28	WEDNESDAY, June 29	THURSDAY, June 30	FRIDAY, July 1
MORNING				
1 Opening Session—Symposium on Recent Progress in Materials Sciences	7 Symposium on Acoustical Fatigue	18 Symposium on Radiation Effects and Radiation Dosimetry	27 Symposium on Low Temperature Properties of High Strength Aircraft and Missile Materials	35 Symposium on Quality of Observations
	8 Symposium on Shear and Torsion Testing	19 Session on Fatigue (Cont.)	28 Session on General Testing	
	9 Symposium on Present Methods of Metallographic Specimen Preparation	20 Session on Metals	Papers on Effect of Nuclear Bombardment of Rubber Materials	
—12:00 noon— Materials Sciences Luncheon	—12:00 noon— 10 President's Luncheon	—11:15 a.m.— 21 Report Session (Reports D-7, D-10, D-12, D-13, D-14, D-15, D-21, D-22, E-4)	—11:15 a.m.— 29 Report Session (Reports C-3, C-13, C-14, C-16, C-22, E-1 E-6)	
AFTERNOON				
2 Symposium on Nature and Origin of Strength of Materials	11 Session on High Temperature (Cont.)	—2:00 p.m.— 22 Symposium on Radiation Effects and Radiation Dosimetry (Cont.)	30 Symposium on Low Temperature Properties of High Strength Aircraft and Missile Materials (Cont.)	—12:30 p.m.— 36 Report Session (Reports D-2, D-4, D-11, D-16, D-17, D-19, D-20, D-24, E-11)
	12 Symposium on Shear and Torsion Testing (Cont.)	23 Session on Metals (Cont.)		—12:30 p.m.— 37 Report Session (Reports B-7, C-1, C-11, C-15, E-2, E-5, E-7, E-14, E-15)
	13 Symposium on Present Methods of Metallographic Specimen Preparation (Cont.)	—3:00 p.m.— Panel Discussion on Low Cycle Fatigue		
—4:30 p.m.— 3 Report Session (Reports A-6, A-7, B-3, C-12, C-18, C-20, D-3)	—4:30 p.m.— 14 Report Session (Reports A-10, B-1, B-4, B-8, B-9, C-4, C-8, C-17)	—4:00 p.m.— 24 Report Session (Reports A-1, A-5, B-2, B-5, B-6, E-3, E-13)	—4:30 p.m.— 31 Report Session (Reports A-3, D-5, D-6, D-23, D-25, D-26, E-10, E-12)	
		25 Report Session (Reports C-7, C-9, C-21, D-1, D-8, D-9, D-18, D-27, F-1)		
	—5:00 p.m.— 15 Gillett Lecture R. C. Dalzell Nuclear Fuel Element Development	—4:30 p.m.— 26 Marburg Lecture Farrington Daniels Solar Energy		
EVENING				
4 Symposium on Nuclear Methods for Measuring Soil Density and Moisture	16 Session on Soils for Engineering Purposes		32 Symposium on Low Temperature Properties of High Strength Aircraft and Missile Materials (Cont.)	
5 Session on Concrete	17 Session on Fatigue		33 Session on Road and Paving Materials	
6 Session on High Temperature		Dinner Dance	34 Session on Cement and Plaster	
	Entertainment Feature "Slides on Africa"			

First Session

9:30 a.m.

Symposium on Recent Progress in Materials Sciences

Recent advances in solid-state theory and application and the relation of structure to properties of materials will be treated in depth by the four speakers in this session. They will describe and interpret what is now known of why materials behave as they do.

Accomplishments and Limitations of Solid State Theory—Harvey Brooks, *Harvard Univ.*

While solid-state theory has been reasonably successful in interpreting and correlating many properties of materials after they are measured, it is still far from being in a position to predict the properties of new compounds of even the simplest sort. The theory has been somewhat more successful in predicting the properties of combinations of materials whose individual homogeneous properties are known from measurement. Similarities and differences between solid-state theory and design theory, with which the engineer is familiar, will be discussed.

The Influence of Surfaces on the Properties of Materials—M. J. Sinnott, *University of Michigan.*

Many of the properties that are of interest to engineers concerned with materials are controlled or influenced by the environment in which the material is to be used or to which it has been exposed in prior processing. These changes might be termed solid-state phenomena, since their effect is reflected in the properties of the solid but they are basically of surface origin. This paper reviews the influence of surfaces, either internal or external, on the physical and chemical properties of materials.

Mechanical Properties of Semiconductors—J. N. Hobstetter, *University of Pennsylvania.*

Semiconductor materials having the diamond structure have recently been found to show extensive plasticity at elevated temperatures. The plastic properties of semiconductors will be correlated with the nature, the generation, and the motion of dislocations in them. It appears that the mutual interactions of structural point defects, and also their interactions with dislocations, play crucial roles in these materials and that these mechanisms can be studied rather easily by virtue of the electrical effects.

Status of Ductile Ceramic Research—E. R. Parker, *University of California.*

Fundamental studies of the mechanical behavior of ionic nonmetallic materials have shown that refractory compounds such as magnesium oxide are inherently ductile at room temperature, with strains in excess of 10 per cent being possible. Recent investigations with such materials have yielded valuable information about how crystals flow plastically and why they fracture. Knowledge about plastic flow and fracture of nonmetallic crystalline materials is being accumulated at a rapid rate. The facts now available will be discussed and correlated, and comments will be made about the probable future of work on ductile ceramics.

Materials Sciences Luncheon

12:00 Noon

Speaker: W. O. Baker, vice-president, Bell Telephone Laboratories, Inc.

Second Session

2:30 p.m.

Symposium on Nature and Origin of Strength of Materials

The second session will contrast with the first in that it will focus on the single property, "strength," and will be conducted in an informal manner which it is hoped will elicit the maximum participation from the audience. The five speakers will approach the strength property from different viewpoints collectively considering all major factors contributing to the strength of solid materials. Audience participation is expected after each paper and at the end of the session.

Dislocation Motions and the Yield Strengths of Solids—J. J. Gilman, *General Electric Co.*

The useful strength of many crystalline solids is limited by plastic yielding. Direct experimental observations have shown that yielding occurs when an applied stress causes dislocations to move at appreciable rates through crystals. Yielding occurs at a sharply defined stress because the velocities with which dislocations move increase very rapidly with increasing applied stress. Many factors have been directly observed to influence dislocation velocities at a given value of applied

stress. These factors thereby influence the yield strength. Some of them are: elastic modulus, dislocation type, glide plane, temperature, impurities, radiation damage, plastic strain.

Fatigue Strength of Crystalline Solids—G. M. Sinclair, *University of Illinois.*

Recent theoretical concepts and experimental studies of the nucleation and propagation of fatigue cracking in crystalline solids will be reviewed. Additional details of the role of dislocation-motion and interaction in fatigue are becoming available through studies involving direct observation of individual dislocations. Results of current investigations of the effects of dislocation-impurity-atom interaction and surface chemical environment on fatigue strength will also be discussed.

Resistance to Creep Deformation and Fracture in Metals and Alloys—Frank Garofalo, *U. S. Steel Corp.*

A review of the theories of creep is presented and discussed in terms of available experimental findings. Theories of void formation and intergranular fracture under creep conditions are also discussed. A summary of the dependence of creep strength and fracture on structure is included.

Brittle Fracture and the Strength of Metals—E. T. Wessel, *Westinghouse Electric Corp.*

The observed brittle-fracture strength of a polycrystalline metal is not a unique basic material property. It is, rather, the gross product arising from complex interrelations of several influential factors and its absolute value is highly dependent upon these factors. The individual and composite effects of the important mechanical and metallurgical variables on brittle-fracture strength are described and discussed. Consideration is given to the development of an understanding of the basic aspects of brittle fracture and the application of this understanding to practical situations.

Size and Shape Effects on Fracture of Solids—George Irwin, *Naval Research Laboratories.*

Mr. Irwin will close the presentation by bringing all together in some degree the relation between fundamental considerations and engineering properties of materials as reflected in strength and fracture.

Third Session

4:30 p.m.

Committee Report Session

A-6 on Magnetic Properties—A. C. Beiler, *Chairman.*

A-7 on Malleable-Iron Castings—W. M. Albrecht, *Chairman.*

B-3 on Corrosion of Non-Ferrous Metals and Alloys—K. G. Compton, *Chairman.*

C-12 on Mortars for Unit Masonry—R. E. Copeland, *Chairman.*

C-18 on Natural Building Stones—L. W. Currier, *Chairman.*

C-20 on Acoustical Materials—R. N. Hamme, *Chairman.*

D-3 on Gaseous Fuels—D. V. Kniebes, *Chairman.*

Fourth Session

8:00 p.m.

(Held simultaneously with Fifth and Sixth Sessions)

Symposium on Nuclear Methods for Measuring Soil Density and Moisture

A brief digest of each paper will be presented by Mr. Bonner Coffman, chairman of the Subcommittee on Special and Construction Tests for Earth Dams and Embankments of Committee D-18 on Soils for Engineering Purposes, after which the subject will be opened for discussion with the several authors serving as panel members. It is believed this procedure for conducting the program will afford particular advantages in presenting the developments of this method of test and the problems incurred.

Application of Nuclear Soil Meters to Compaction Control for Air-field Pavement Construction—P. F. Carlton, *Corps of Engineers.*

Nuclear soil meters now available can measure the moisture content and density of soils within the average accuracies required for engineered construction. This paper describes the use of surface-type nuclear soil meters for compaction control testing during the construction of pavements at Clinton County Air Force Base, Ohio.

Engineering models of the P-21 surface moisture probe and the P-22 surface density probe, manufactured by the Nuclear-Chicago Corp., were used. Both cohesive and granular soils were tested. It is concluded that the reliability of the nuclear method was comparable to that of conventional testing procedures for compaction control, time requirements per test were greatly reduced, and radiation hazard to operating personnel was negligible.

The Use of Nuclear Test Methods in Civil Engineering—T. W. Van Zelst, *Soiltest, Inc.*

The practical applications of the newly developed nuclear apparatus for rapid moisture and density measurements of soil are described. Typical examples of use of the instruments in research, education, and construction work are presented. Sections of the paper are con-

cerned with the economics involved in the use of the new nuclear testing techniques.

Experiences with Nuclear Moisture and Density Surface Probes on O'Hare Field Project—J. P. Gnadinger, *Soil Testing Services, Inc.*

Surface instruments for nuclear density and moisture content measurements have been used on compaction control operations at O'Hare Field in Chicago, Ill., and the information has been correlated with similar data obtained through the sand cone method of field density determination and the oven drying method of moisture determination. The correlation to date is not acceptable, with deviations in moisture content as high as 10 per cent of the dry weight of soil, and deviations in field densities as high as 17 per cent. Indications are that the poor correlation can be partially accounted for by difficulties with the equipment, and also by an apparent need to calibrate the equipment for each soil type.

Design and Calibration of a Neutron Moisture Meter—K. N. Burn, *National Research Council of Canada.*

A probe using an actinium-beryllium neutron source and a scintillation-type detector was designed and built for use in determining the moisture density in soils below the surface of the ground. Use of portable, battery-operated scalar permits use of the equipment where there is no available a-c supply.

Since the neutron moisture meter depends upon the physical interaction of neutrons with hydrogen atoms, thought was given to calibrating the instrument in media other than actual soils, the advantages of using substitute materials being better uniformity and better control of both bulk density and distribution of hydrogen atoms. Requirements of the artificial media are discussed and those adopted for calibration are described.

Nuclear Methods for Determining Density and Moisture of Soils—O. K. Neville, *Nuclear-Chicago Corp.*

The measurement of moisture and wet density in soils by the nuclear method for both absolute and relative determinations is covered. Wet density can be obtained with the density gages, which use the principle of gamma-ray back-scattering. Moisture content can be obtained with the moisture gages, which use the principle of fast-neutron moderation by the hydrogen of water.

Nuclear gages offer: rapid results, high accuracy, large-volume measure, complete portability, economy, and they are nondestructive. They are being used in such fields as: compaction control of airfields, embankment studies, evaluation of borrow pits, studying freezing and thawing effects on foundations, moisture-swelling effects of soils on foundations, and water penetration.

Comparison of Nuclear and Sand Cone Methods of Density and Moisture Determinations for Four New York State Soils—Sidney Mintzer, *New York Department of Public Works.*

This paper reports the results of the preliminary phase of a testing program being conducted by the Bureau of Soil Mechanics of the New York State Department of Public Works, investigating the performance of the nuclear method for density and moisture determinations on New York State soils. Field tests were conducted on three highway projects under construction, involving four basic soil types: fine sand, silt with some clay, sand and gravel, and a glacial till. Concurrent tests were run, using the nuclear method and the sand-cone method. The results obtained using the two methods are compared.

Evaluation of Nuclear Moisture Density Testing Equipment—W. N. Carey, Jr., J. F. Shook, and J. F. Reynolds, *Highway Research Board.*

The AASHTO Road Test Materials Branch has performed an extensive field experiment in which nuclear surface gage equipment and techniques developed at the Road Test for measuring soil density were studied during the construction of the crushed limestone base courses for the Road Test flexible pavements. This investigation showed the nuclear equipment to be somewhat superior to conventional techniques for in-place density testing of homogeneous material. The Branch has also conducted a laboratory experiment in which the Road Test density gage, a commercial density gage, and a commercial nuclear moisture gage were studied along with conventional techniques over a range of soil types and densities. The results of this investigation and some recommendations for further evaluation and calibration work are also included.

Use and Reliability of Radiation Methods in Soil Measurements—H. Gray, *Ohio State Univ.*

This paper deals with the application of two well-established principles of atomic physics to practical field measurements: (1) The moderation or "slowing" of fast neutrons radiated from a source by collision with hydrogen atoms, and (2) The Compton effect, or scattering of gamma radiation by collision with electrons in the surrounding medium. Various methods have been devised to use the first principle in determining water content or quantity of hydrocarbons present in a material, and to use the Compton effect in determining the density of the surrounding region. This paper presents data on the statistical variation of observations made by the radioactive methods. It is found that for certain purposes the reliability obtained from a small number of measurements is less than that desired, and that further improvement is needed in the type of apparatus used to apply the foregoing principles to practical measurements.

(Held simultaneously with Fourth and Sixth Sessions)

Session on Concrete

Presentation of Sanford E. Thompson Award.

The Effects of Early Freezing on Low-Density Aggregate-Type Concrete—I. A. Benjamin and G. D. Ralliff, Jr., *Granco Steel Products Co.*

Small concrete slabs were cast outdoors, and slabs from the same mix were exposed to a comparable temperature cycle in a freezer. Temperatures were recorded inside the slabs up to the time of freezing. Damage was measured by the Proctor penetration test, an asphalt adhesion test, and tactile observations. Freezing affected the interior and the surface differently. The interior suffered severe strength retardation but little permanent damage if it froze before age 5 hr. The surface suffered scaling or complete loss of strength if it froze before an age of about 20 hr. Outdoor freezing was more damaging than artificial freezing with the same temperature cycle. Slabs not damaged during the initial freezing cycle were not damaged by subsequent cycles of freezing and thawing during a winter's exposure.

Testing Performance of Stationary Concrete Mixers—Glenway Maxon, *Consulting Engineer.*

Some of the methods used to test concrete mixer performance are reviewed briefly. New methods of selecting the criteria and establishing tolerances that are desirable and can be met, is the goal of the Task Force on Mixing Time. Data and curves are submitted. Quality control, properly set up, can unite the interests of the concrete manufacturer and the contracting engineer. The equipment manufacturer is becoming cognizant of the value of these tests. Simple checks carried on from day to day that will indicate changes in the performance of the mixing equipment are needed.

Investigation of Alkali Reactivity of the Fine and Coarse Aggregates of Northern Illinois—J. F. Weigel, *Medusa Portland Cement Co.*

The alkali expansion characteristics of the fine and coarse aggregate from six major sources in northern Illinois were studied. Structures in which the suspect aggregates had been used over a period of years were inspected, and six different test methods were used to evaluate reactivity. Results given include length changes of test specimens at ages up to 1½ yr and expansion measurements of concrete in structure at ages up to 2 yr.

Inspection of existing structures and a review of service performance of aggregates failed to disclose any distress attributable to alkali reactivity. Results of expansion measurements of mortar bars, concrete prisms, and concrete in structures, made with high alkali cement and suspect aggregates, show no deleterious expansion. However, based on petrographic and chemical evaluation, several of the aggregates would be considered borderline and several, alkali reactive.

Performance Tests of Field Concrete Mixers—I. Narrou, *Corps of Engineers.*

This study was made to determine the performance of two tilting-type stationary concrete mixers. Evaluation of performance for five different periods of mixing was based on tests for uniformity of cement, aggregate, water, and air content, and workability and strength of concrete samples from the front, middle, and rear of the mixers. The tests indicated variable performance for the two mixers. Indications are that the evaluation of mixer performance should be based on tests of mortar samples obtained from the concrete to determine cement content, air content, water content, and air-free unit weight. Only the percentage of coarse aggregate need be determined on the concrete samples. Tentative limits for variations in test results are indicated.

Influence of Physical Characteristics of Aggregates on Durability of Concrete—G. Verbeck, *Portland Cement Assn.*

The durability of concretes made with different aggregates depends upon the rate at which these aggregates become critically saturated in the concrete and the physical response of these aggregates to freezing. The mechanism of saturation of aggregates is considered in terms of their physical characteristics (such as porosity, permeability, and pore-size distribution), and the characteristics of the mortar (permeability and thickness of cover) protecting the aggregates from water. The effect of freezing of various saturated aggregates on concrete durability is shown to depend upon the pore characteristics of the aggregate and the rate of freezing of the concrete. The validity of certain types of laboratory tests of the frost resistance of aggregates and concretes is questioned.

(Held simultaneously with Fourth and Fifth Sessions)

Session on High Temperature

The Role of Refractory Metals in Superalloys—E. R. Parker, *University of California.*

An understanding of the basic mechanism of creep is an essential prerequisite for understanding how the elements molybdenum, tungsten,

ten, tantalum, and columbium prolong the creep life of superalloys. Diffusion and dislocation climb are discussed briefly. The influence on creep of such factors as grain size elements in solution, the presence of a second phase, and heat treatment are also discussed. Data presented show that both molybdenum and tungsten are important solid-solution strengtheners. Tantalum and columbium are particularly effective strengtheners because they form stable carbides that interfere with the movement of dislocations. Complex alloys are also shown to be stronger than simple ones. Also discussed are the reasons why the most effective strengthening is produced by a combination of solid solution strengtheners and carbide formers. The behavior of commercial high-temperature alloys is explained in terms of the modern physical theory of creep.

The Relaxation Characteristics of Inconel at Elevated Temperatures—C. R. Kennedy and D. A. Douglas, Oak Ridge National Laboratory.

A newly developed stress-relaxation machine can provide very precise results throughout the useful temperature range of common structural metals. The advantages of this machine are dynamic response, sensitive control, and low cost.

The relatively short time, single specimen, relaxation test can be used to generate reliable strain-rate values over a wide range of stresses and temperatures. Although the relaxation test is not a substitute for the creep test, it does provide a check on the accuracy of the law assumed for the constant-stress creep data and also provides additional information to assist in establishing more exact models to describe the deformation process.

Creep Rupture Properties of a Carbon Steel and a Low-Alloy Steel at 1200 to 1800 F—P. N. Randall, Standard Oil Company of Indiana.

Creep-rupture data are given for a carbon steel (ASTM A201-A) and a low-alloy steel (ASTM A387-C) at ten temperatures between 1200 and 1800 F and a stress of 2500 psi. The tests were run on constant-stress equipment, both in air and in vacuum. The results show the possibility of distortion and rupture of a piece of equipment overheated in service to the austenitizing temperature to be less than that predicted from the known effects of temperature in the ferritic range. The superiority of the low-alloy steel for service at temperatures up to 1200 F disappeared at the higher test temperatures.

Predicting Creep Deflections of Beams—C. A. Schulte, Arthur D. Little, Inc.

A simple method is proposed for predicting beam deflections under creep conditions from tension creep data. The results of the method are in good agreement with test data on certain plastics. It is suggested that the method may apply equally well with metals.

An Improved Microhardness Tester for High-Temperature Use—J. H. Westbrook, General Electric Co.

The design, construction, and operation of an improved high-temperature microhardness tester are described. Examples of various applications of the instrument are given which demonstrate its capabilities and the variety of problems for which it may be used.

An Examination of High-Temperature Stress-Rupture Correlating Parameters—F. J. Clauss, Lockheed Aircraft Corp.

Attempts to correlate high temperature with stress-rupture in metals have appeared frequently in the literature during the past 10 years. Each method of correlation suggested a different correlating parameter, and each author has sought to justify one parameter over the others. Considerable confusion has resulted, and no agreement has been reached as to which parameter is best. Despite differences of approach in developing correlations and in the final parameters derived, careful analysis shows that there is actually a close similarity among the parameters. These areas of common agreement are explored to demonstrate the limitations of the various parameters and to establish a sound basis toward unifying and improving them for correlating and extrapolating test data.

(Continued in Eleventh Session)

TUESDAY, JUNE 28

Seventh Session

9:00 a.m.

(Held simultaneously with Eighth and Ninth Sessions)

Symposium on Acoustical Fatigue

The recent trend toward higher thrust in aircraft engines and higher speeds in airframes has greatly increased the magnitude of acoustical energy radiated by various types of noise sources. This acoustical energy is now large enough in many situations to excite fatigue-producing vibrations, a phenomenon now identified as acoustical fatigue or sonic fatigue. Looking to the future, the acoustical environment that structures are likely to encounter will become more severe. Thus, unless structures are designed specifically to resist acoustical fatigue, serious failure problems may be encountered.

The purpose of this symposium is to discuss the various properties of materials important in acoustical fatigue, the effect of these proper-

ties on acoustical fatigue life, and simulated environmental testing procedures for appraising acoustical fatigue properties.

Material Properties which Affect Acoustical Fatigue Life and the Role of Damping—W. J. Trapp, Wright Air Development Div. and B. J. Lazan, University of Minnesota.

This paper discusses the cause and nature of acoustical fatigue, reviews recent experiences, and views future expectations. The origin of acoustical and aerodynamical excitations, how they induce structural vibrations, and the properties of materials and configurations which affect the response and fatigue life of acoustically excited structures are considered. The paper also describes the role of structural damping in minimizing response to acoustical excitation and reviews various material and interface damping mechanisms and their relative importance in the types of structural configurations exposed to acoustical excitation.

Prediction of Acoustic Fatigue Life—H. C. Schjeldrup, National Engineering Science Co.

Current procedures used by the airframe industry for predicting fatigue life of structures loaded by high-energy acoustical noise are reviewed. Deficiencies in the methods are discussed and future work is suggested. The need for spectrum-type fatigue testing is emphasized.

Fatigue of Structural Metals Under Random Loading—A. M. Freudenthal, Columbia Univ.

The fatigue life under randomly varying stress amplitudes is discussed in terms of the "interaction" between infrequent, high stress amplitudes and the dominant, low stress amplitudes. An "interaction factor" is developed with the aid of which the validity of a pseudo-linear rule of cumulative damage is demonstrated for structural aluminum.

The statistical aspect of fatigue under random loading is considered and a relation established between the distributions of fatigue lives under randomly varying and under constant stress amplitudes as well as between the form of the distribution of fatigue lives and the "risk" of fatigue failure.

The Fatigue Damaging Effect of a Random Load—Waloddi Weibull, Bockamöllan, Sweden.

It has been stated that the frequencies of a random load are of minor importance in predicting its damaging effect. Consequently, neither a power spectrum nor any other frequency representation alone can serve as a proper measure of the specific fatigue damage. It has also been postulated that a representation providing necessary and sufficient information on the fatigue damage has to be based on the statistical distributions of the ordinates of the extremes occurring in the random load. These statements are further pursued, and results from statistical analyses of various recordings of actual service loads establishing adequate distribution functions of the extremes are presented.

Experimental Techniques and Equipment in Acoustical Fatigue Research and Development—D. M. Forney, Jr., Wright Air Development Div.

A general review is made of the various testing techniques and facilities used in the aircraft industry in the development and improvement of the acoustical fatigue resistance of aircraft hardware. Attention is also given to several of the important academic research efforts being made to answer many of the basic mechanistic questions concerning acoustical fatigue phenomena. Some of the special and unique experimental facilities and apparatus developed for research work in this and other countries is covered in the discussion.

Eighth Session

9:00 a.m.

(Held simultaneously with Seventh and Ninth Sessions)

Symposium on Shear and Torsion Testing

The objectives of this symposium are: (1) to obtain detailed descriptions of new or existing shear and torsion test methods as used on a wide variety of materials, (2) to determine the test variables in these test methods and to evaluate the effect of these variables on the test results, (3) to compare test results using different test techniques or conditions, and (4) to describe the advantages and disadvantage of the various test techniques. It is expected that the information presented in this symposium will be helpful to Subcommittee 25 of Committee E-1 in establishing tentative recommended shear and torsion test practices, and will also provide a useful reference on the many aspects of shear and torsion testing.

Maximum Shear Strain Measurements and Local Yield Point Determination by the Use of the Photoelastic Coating Technique—Felix Zandman, The Budd Co.

Photoelastic coatings have been successfully used for stress-analyzing structures. The method consists of coating the part with a photoelastic layer and analyzing the resulting fringe pattern with standard photoelastic techniques. Thus the complete strain distribution can be obtained on the surface of the tested specimen.

Several examples of maximum shear stress measurements and determination of local yield points by the use of this technique are described. The advantages and limitations of the method are discussed.

TUESDAY, JUNE 28 (Continued)

Stress Distribution in Single-Shear Sheet Specimens—C. S. Yen, Douglas Aircraft Co., Inc.

The direction and magnitude of principal stresses in standard and modified shear-sheet specimens were determined, using photoelastic coating technique. It was found that this type of specimen may be used for determining shear strength, but not shear strain.

The Design and Development of a Tensile Loaded Shear Specimen—E. J. Zapel, Boeing Airplane Co.

The development of a tensile-loaded shear specimen test technique is described. Photographs of the strain patterns obtained in the photoelastic study are included. Room-temperature test results for brittle and ductile materials are tabulated and compared with the results obtained from conventional shear tests on the same material.

An Investigation into the Load Transfer and Shear Failure of Spot Welds—N. A. Freytag, The Budd Co.

Photostress coatings were applied to polished cross-sections of spot welds in joints stabilized to prevent twisting in the plane of the welds under load. By observing this "edge view" of a weld under tensile load and with the correct lighting conditions it was possible to distinguish the stress patterns in and around the weld. Photographs taken at various percentages of load dramatically illustrate stress concentrations at the weld zone. Differences between single and double shear loading are illustrated and described. The effects of surface indentation at the spot weld, sheet separation, dissimilar metal thicknesses, and weld defects are also discussed.

Bonded Metal-to-Metal Shear Testing—L. R. Lunsford, Convair.

This paper compares the advantages and disadvantages of the various types of shear specimens. The properties actually being tested are compared with the properties of bonded joints which actually allow failure to take place. The majority of the presently used methods are empirical, and serious errors could be obtained in extrapolating this information to other materials and environments. A method of predicting joint strength from basic material properties is presented.

On the Lap-Joint Shear Test for Metal-to-Metal Bonds—R. S. Shane, General Electric Co.

During studies on the preparation of aluminum, stainless steel, and magnesium surfaces for adhesive bonding, modifications were made in the lap-joint shear test. These modifications in the standard test techniques resulted in a mean derivation of 5 per cent as compared with values of up to 40 per cent usually encountered.

Data are presented on (1) choice of a test adhesive, (2) effect of parallelism of platens, (3) uniformity of heating of platens, and (4) effect of location of test coupon within a specimen. Satisfactory methods of preparing metal surfaces for testing adhesives are given. A method for modifying a manual Dillon tester to permit uniform application of tensile stress is also described.

(Continued in Twelfth Session)

Ninth Session 9:00 a.m.

(Held simultaneously with Seventh and Eighth Sessions)

Symposium on Present Methods of Metallographic Specimen Preparation

In recent years the metallographer has been called upon to examine many new and hitherto commercially unused metals and alloys in increasing quantities. Not only must he prepare his specimens more rapidly but because of the wider use made of his field he must have better surface preparation than ever before. In fact, there has never been a real advance in metallography without a previous improvement in the prepared surface. Several of the new methods now in use, including both those used for the rapid polishing of materials and for the preparation of extremely fine surfaces as well as remote-control methods, are described in this symposium.

Introduction—Mary R. Norton, Watertown Arsenal.

Mechanical Polishing of Metallographic Specimens—H. S. Link, U. S. Steel Corp.

The primary purpose of metallographic polishing is to produce an optically flat surface, suitably free of artifacts, for subsequent microscopic examination. How this is accomplished is of secondary importance. With modern aids, such as automatic polishing machines and electropolishers, a technician with a minimum of training can generally prepare satisfactory specimens in a relatively short time. But this type of advanced equipment is not essential except in special cases. Examples are shown of the type of work that experienced metallographers can produce using polishing wheels that are much the same as those used since the earliest days of metallography.

Use of Diamond Abrasives in Metallographic Problems—E. C. Olden, Frankford Arsenal.

A polishing procedure using diamond abrasives was developed for assignments representing the three major problem areas in metallo-

graphic preparation of ferrous and non-ferrous alloys, namely, loss of nonmetallic inclusions, surface distortion, and insufficient flatness of field. Results indicate that the use of diamond abrasives minimized, to a large degree, polishing difficulties ordinarily experienced in these problem areas. It was also found that with this polishing medium, one basic procedure could be used, avoiding the need of specialized techniques and experience often required with conventional abrasives.

Polishing for Retention of Inclusions—C. G. Brandenburg, General Motors Corp.

A study was made of the procedures used by nine laboratories in preparing metallographic specimens for retention and identification of inclusions in steel in accordance with the procedure required by ASTM E 45-51. The review illustrates the different techniques used to produce the same result—a properly prepared polished surface free from scratches, stains, disturbed metals, and inclusion pull-out or drag-out. The economics of various methods are not compared; rather, the various techniques used in the laboratories are compared so that metallographers might improve their present methods and reach a more common over-all method in preparing metallographic specimens.

Chemical and Electrochemical Polishing of Metallographic Specimens—F. M. Cain, Jr., Nuclear Materials and Equipment Co.

Chemical polishing is a practical and versatile means of polishing and developing the microstructure of a metal quickly without the use of mechanical or electrolytic polishing. Suitable for a variety of different metals and alloys, the technique is especially useful with materials that do not readily lend themselves to conventional methods. Applications of particular advantage are the nondestructive microscopic examination of large sections and remote metallography of irradiated specimens. The theory of chemical polishing is described, apparatus, techniques, and bath compositions are listed, and photomicrographs are shown for a number of different materials.

(Continued in Thirteenth Session)

Tenth Session 12:00 noon

Luncheon Session

President's Address, Introduction of New Officers, 40-Year and 50-Year Members Recognition, Report of Board of Directors, Awards.

Eleventh Session 2:30 p.m.

(Held simultaneously with Twelfth and Thirteenth Sessions)

Session on High Temperature (Continued)

Strength of Structural Alloys Under Conditions of Rapid Heating and Rapid Loading—D. W. McDowell, Jr., International Nickel Co., Inc., and J. R. Kattus, Southern Research Inst.

The rapid tensile and short-time creep properties are presented for three commercial nickel-base sheet alloys, three commercial stainless steel sheet materials, and one experimental stainless steel cold rolled at -105 F. The specimens were heated to test temperatures up to 2000 F in 30 sec or less. Tensile tests were made at a strain rate of 0.1 in. per in. per sec; creep tests were made at tensile stresses that caused rupture in times ranging from 1 to 30 min.

For short-time mechanical strength, the high-strength stainless steels are superior to the nickel alloys at temperatures up to about 1100 F. In this temperature range, type 304 stainless steel cold rolled at -105 F has higher strength than any commercial grade of stainless steel. At higher temperatures the nickel alloys are superior.

Compression Testing of Sheet Utilizing Rapid Heating—R. W. Fenn, Dow Chemical Co.

Equipment developed for the determination of short-time compression creep data and compression isochronous stress-strain curves at elevated temperatures is described. Methods are discussed for handling such experimental problems as: axial alignment, specimen support, resistance-heating of test specimens, control of thermal gradients, and automatic measurement of stress and strain. A method of calibrating the stress and strain measuring equipment during testing is described in detail.

Compression-creep data for a magnesium sheet at elevated temperatures after heating for approximately 1 min. are presented for test times of 5 sec to 15 min. and strains up to 2 per cent. Where possible, these data are compared with tension data obtained under equivalent heating and loading conditions.

Preliminary Evaluation of Thermocouple Attachment Methods for Radiant Heating Applications—J. F. Burcham, Lockheed Aircraft Co.

The accuracy of thermoelectric temperature measurements made on surfaces exposed to radiant heating is dependent upon the method used to attach the thermocouple to the surface. Eight methods of attachment designed for application by semi-skilled laboratory technicians are investigated. Each installation is evaluated primarily on

the basis of accuracy; but reliability, ease of installation, and surface-continuity effects are also considered. Estimated errors for heating rates to 50 Btu per sq ft per sec are presented, based on measured and calculated temperature gradients in a thin panel subjected to radiant heating on one surface.

Application of Induction Heating to Short-Time Elevated-Temperature Tensile Testing—A. P. Levitt and A. G. Martin, Watertown Arsenal.

Techniques and apparatus were investigated and developed for conducting short-time, elevated-temperature tension tests using high-frequency induction heating. Metal specimens were heated rapidly to a predetermined temperature and then loaded at various strain rates. Proportional temperature-control equipment for the induction heater was developed. Tension-test data were obtained at 600, 800, and 1000 F on 120 plain and welded titanium alloy specimens. Typical results are given, and the limitations and possibilities of the techniques are discussed.

The Evaluation of Resistance Strain Gages at Elevated Temperatures—R. L. Bloss, National Bureau of Standards.

The paper describes methods, equipment, and techniques which have been developed for determining the probable behavior of resistance strain gages at temperatures up to 1500 F. The gage characteristics discussed are gage factor and its variation with temperature, time- and temperature-dependent resistance changes, behavior at strain levels up to 0.01, fatigue life, and behavior under transient heating rates as high as 50 F per sec. Examples of results obtained are shown, and suggestions are given on the selection of gages for specific applications.

Stress Relaxation in Engineering Materials—A. M. Freudenthal, Columbia Univ.

The phenomenon of stress-relaxation is discussed in relation to its physical origin, its mathematical representation in one as well as in three dimensions, and its experimental determination, with particular emphasis on the interrelation between creep and relaxation. It is shown that neither the direct relaxation test nor the conventional conversion of creep into relaxation data provide reliable or useful information concerning the relaxation behavior of the material.

Report of Joint Committee on Effect of Temperature on the Properties of Metals—J. J. Kanter, Chairman.

Twelfth Session 2:30 p.m.

(Held simultaneously with Eleventh and Thirteenth Sessions)

Symposium on Shear and Torsion Testing (Continued)

Preparation of Metal Surfaces for Adhesive Bonding—R. S. Shane, General Electric Co.

Recipes for the preparation of aluminum, stainless steel, and magnesium for adhesive bonding are presented, together with illustrative data showing the reliability of results. Statistically significant tests justify the conclusion that these recipes are satisfactory.

Shear and Torsion Tests Used at U. S. Forest Products Laboratory for Wood, Plywood, and Sandwich Constructions—E. W. Kuenzi and W. G. Youngquist, U. S. Forest Products Laboratory.

This paper describes the test methods used at the U. S. Forest Products Laboratory, traces the history of development of some of the methods, and discusses their advantages and disadvantages. An analysis of the stress conditions in the test specimens is presented for some of the tests. Discussed and illustrated are the shear tests for solid wood; the plate shear, panel shear, "rolling" shear, and tubular torsion tests for plywood; the plywood glue shear, wood glue joint shear, metal lap joint shear, and torsion test of adhesives for metals; and the shear tests for sandwich constructions and cores.

The Study of High Polymers by Means of the Torsion Pendulum—N. G. McCrum, E. I. du Pont de Nemours & Co., Inc.

A description is given of the construction and mode of operation of a torsion pendulum that has been used to study high polymers. The pendulum measures both the torsion modulus and the logarithmic decrement. The measurements may be made over an extended temperature range at frequencies between 0.3 and 3 cps. The theory is discussed in detail including corrections for tensile stress.

A Technique for Torsional Testing of Refractory Materials at Temperatures up to 2800 C—C. E. Waller and M. L. Stehsel, Aerojet-General Corp.

A technique for torsion testing of some refractory materials at temperatures from ambient to 2800 C is described. A carbon resistance furnace and auxiliary devices for measuring and recording torsional stress-strain, creep, and stress-relaxation properties in an inert atmosphere are described. Some results obtained from evaluating a commercial graphite and a uranium-impregnated graphite are shown, demonstrating the suitability of this technique for determining large stresses and strains. Limitations of the equipment in determining small strains and stresses, due to mechanical friction and inertia, are mentioned as well as inaccuracies in determining true torsional stresses and strains in the plastic range inherent in the use of a solid, round specimen.

Discussion and Comments—R. F. Klinger, Wright Air Development Div.

Thirteenth Session 2:30 p.m.

(Held simultaneously with Eleventh and Twelfth Sessions)

Symposium on Present Methods of Metallographic Specimen Preparation (Continued)

The Automatic Polishing of Metallographic Specimens—R. L. Anderson, Westinghouse Electric Corp.

Automatic polishers and automated methods for the preparation of metallographic specimens are discussed. The theories and mechanism of specimen polishing are also briefly discussed. Currently available automatic polishers are described and, where available, techniques for their use are presented. Representative results from some of these polishers are also shown. The arrangement of automatic polishers used at the Westinghouse Research Laboratories is also described.

The Use of Vibratory Polishing for Metallographic Sample Preparation—G. R. Grieger, Jones & Laughlin Steel Corp.

The principles of vibratory polishing are discussed—mechanical, electrochemical, types of cloth, and specimen weight. Comparisons are made with prior metallographic techniques. Ease of use, the standardization of techniques, the versatility and the relatively large numbers of samples that can be handled are some of the advantages of vibratory polishing. The long time required for a single sample and the electrochemical effects have not been serious enough limitations to invalidate the technique. The uses of vibratory polishing in several metallographic areas are listed. Normal metallographic sample preparation is described, and special examples of thin foils for microradiography and the first stages of electron microscopy transmission samples are shown. The establishment of a merit rating for the various polishing techniques is discussed in terms of X-ray and microhardness tests.

Application of Vibratory Polishing in Hot Cell Metallography—E. J. Long, Jr., and R. J. Gray, Oak Ridge National Laboratory.

Vibratory polishing has proved to be useful as a complementary tool to standard metallographic techniques. Because of several inherent features in this mode of polishing the technique is applicable to the metallographic preparation of high-radiation-level specimens. The changing of bowls and cloths required for remote-control operation demanded a redesign of the polishers. During the redesign period various problems such as compensation for weight and geometry changes were solved.

Summary—L. L. Wyman, National Bureau of Standards.

Fourteenth Session 4:30 p.m.

Committee Report Session

A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys—L. L. Wyman, Chairman.

B-1 on Wires for Electrical Conductors—D. Halloran, Chairman.

B-4 on Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts—E. I. Shoberg, II, Chairman.

B-8 on Electrodeposited Metallic Coatings—C. H. Sample, Chairman.

B-9 on Metal Powders and Metal Powder Products—J. L. Bonnano, Chairman.

C-4 on Clay Pipe—C. R. Velzy, Acting Chairman.

C-8 on Refractories—J. J. Hazel, Chairman.

C-17 on Asbestos-Cement Products—W. V. Friedlaender, Chairman.

Fifteenth Session 5:00 p.m.

Gillett Memorial Lecture

Nuclear Fuel Element Development

R. C. Dalzell, Atomic Energy Commission

This Lecture, established in 1951, is jointly sponsored by ASTM with Batelle Memorial Institute. It commemorates Horace W. Gillett, one of America's leading technologists and metallurgists and the first Director of Batelle. The Lecture is delivered annually at a meeting of the Society, the first one having been given at the Fiftieth Anniversary Meeting, June, 1952. The Lecture will cover subjects pertaining to the development, testing, evaluation, and application of metals. [See abstract on p. 10.]

TUESDAY, JUNE 28 (Continued)

Sixteenth Session

8:00 p.m.

(Held simultaneously with Seventeenth Session)

Session on Soils for Engineering Purposes

Presentation of C. A. Hogentogler Award.

Overconsolidation Effect of Compaction on Direct Shear Strength—
R. W. Cunney and R. C. Sloan, U. S. Army Engineer Waterways Experiment Station.

Results of consolidated-drained direct-shear tests including high normal stresses are reported. Tests were performed on saturated lean clay specimens compacted to 95 per cent standard density by either dynamic or static efforts and at water contents varying from dry to wet of optimum. The specimens were sheared by controlled stress or controlled strain.

The shear strengths below normal pressures of 3.7 tons per sq ft were influenced by overconsolidation resulting from compaction. Shear-strength values selected on the basis of the conventional tests would be entirely within the range of this influence and would be higher than that indicated by tests conducted with higher normal pressures. The overconsolidation effect increases with increasing water content within the range used for this study.

Observed Settlement of Soft, Fine-Grained Soils—E. J. Zegarra,
M. W. Kellogg Co.

Three observations were made (in Delaware, Texas, and Venezuela) of the progress and magnitude of settlement of soft, organic, fine-grained soils under the influence of superimposed fills. Data from borings and from laboratory tests on specimens of the materials are analyzed for estimating the magnitude and rate of settlement. Observations were made, in two cases, by plates whose vertical movement indicated the total settlement, and in one case piezometer wells were used in addition to settlement plates. Although the results indicate that fair agreement exists between computed and observed settlements, the rate of progress in the field is nowhere near correct. It is suggested that the characteristics of organic soils and the disturbance caused by testing for consolidation account for the discrepancies.

The Compressive Strength of Remolded Niagara Clay—D. J. Bazett and S. W. Smotrych, The Hydroelectric Power Commission of Ontario

An extensive program of triaxial compression testing was carried out on a remolded Niagara clay as a check on testing procedures and methods. The investigation included a comparison of drained tests and undrained tests with pore-pressure measurements, and was carried out on both normally and overconsolidated samples. The results indicate that shearing parameters (c' and ϕ') in terms of effective stresses are identical as obtained from drained or undrained tests for either normally or over consolidated material. The pore-pressure behavior is shown to be highly dependent upon the method of sample preparation and stress history, and the established relationship between the test methods is used as a check on the procedures used.

Duplication of Prototype Stress-Strain Relations by Laboratory Tests—R. G. Ahlvin and D. N. Brown, U. S. Army Engineer Waterways Experiment Station.

Studies of the distribution of stresses and strains in soil masses conducted by the U. S. Army Engineer Waterways Experiment Station have included measurement of stresses and deflections in two full-scale test sections. These stresses and deflections have been used to develop stress-strain curves which are representative of prototype conditions.

Any rational analytical method involving soil stress-strain relations will require a means of evaluating the stress-strain characteristics of soil from laboratory specimens. For this reason, this paper presents and points out the importance of the prototype stress-strain relations, describes test methods used in attempting duplication of prototype curves, and presents methods by which each prototype curve was substantially duplicated.

The Importance of Freezing Rate on Frost Action in Soils—E. Penner, National Research Council of Canada.

The effect of rate of freezing on frost action was studied under laboratory conditions for the saturated and near-saturated moisture condition. The rate of freezing was measured both in terms of heat flow and rate of frost penetration. Three soils of widely differing properties were used to bring out major differences in behavior.

The results show a positive relationship between net heat flow or frost penetration rate and heaving rate. For the three soils studied at high moisture contents, increasing the rate of heat flow away from the freezing plane in all cases increased the rate of moisture flow to the freezing plane and consequently also the heaving rate.

Seventeenth Session

8:00 p.m.

(Held simultaneously with Sixteenth Session)

Session on Fatigue

Elevated-Temperature Tensile and Fatigue Behavior of Unalloyed Arc-Cast Molybdenum—G. W. Brock and G. M. Sinclair, University of Illinois.

Tension and fatigue tests were carried out to explore the possible effects of interaction between interstitial atoms and dislocations on fatigue behavior of recrystallized molybdenum containing small amounts of interstitial elements. No increase in tensile strength corresponding to that found in the "blue brittle" range in steel was observed as the test temperatures were raised from -300 to 1800 F. However, values of the upper and lower yield point remained essentially unchanged over the temperature range 200 to 400 F. The presence of a "knee" in the S -log N fatigue diagram over the temperature range 75 to 875 F suggests that strain aging may be influencing the fatigue behavior and may also be responsible for the high values of fatigue ratio (0.65 to 0.72) observed at these temperatures.

Fatigue Properties of Some High-Strength Steels—H. E. Frankel and J. A. Bennett, National Bureau of Standards, and C. M. Carman, Frankford Arsenal.

The rotating-beam fatigue properties of 18 high-strength low-alloy steels were investigated. Except for the high-silicon steels, the maximum fatigue strength was generally obtained for the lowest tempering temperature. The steels containing 1.3 per cent copper had higher maximum fatigue strengths than any of the other materials. It is suggested that the generally superior fatigue properties of the copper-bearing materials may be due to the precipitation of copper under the influence of the fluctuating stress.

Design Applications for Improving Fatigue Resistance of Airplane Structures—C. R. Smith, Convair.

Methods for prolonging fatigue life of built-up structures are discussed. Lessening load on first rows of rivets in joints, providing interference fits, or a combination of both were found to be helpful. Test data are presented showing that the ratios of effective spring constants of pressed-in bushings to those of surrounding structure can be used for predicting fatigue life. Effects of static overloading prior to testing are also discussed.

The Effect of Frequency and Physical Structure Upon the Solid Damping Property of Materials—H. L. Milligan, Boeing Airplane Co.

Damping studies were conducted on a number of plastics and several cast and sheet metals, in both the tempered and annealed condition, as part of a continuing program to develop improved methods of reducing the damaging vibration energy generated in ramjets and rocket engines. The resonant frequencies of the specimens ranged from 20 to 800 cps, and the vibration energy level was varied to determine the relationship between damping and frequency at certain stress levels. It was found that damping capacity decreases as the frequency becomes higher under conditions of equal bending stress. In addition, sheet metals, regardless of heat treatment, exhibited greater damping capacity than cast metals. These test results can be interpreted in dislocation theory by a consideration of the quantity and mobility of dislocations present.

(Continued in Nineteenth Session)

WEDNESDAY, JUNE 29

Eighteenth Session

9:00 a.m.

(Held simultaneously with Nineteenth and Twentieth Sessions)

Symposium on Radiation Effects and Radiation Dosimetry

The application of nuclear energy to problems in materials and materials testing, in addition to creating a few new problems, is adding some unusual aspects to many familiar problems that are requiring the attention of increasing numbers of the Society's committees. Two of the problem areas, radiation effects and radiation dosimetry, will be discussed in this symposium. Radiation effects refers broadly to the changes in properties of materials due to exposure to nuclear radiation. It is perhaps the most dramatic of the problem areas in that it involves the influence of an additional environment on material behavior. Radiation dosimetry, the measurement of the environment of nuclear particles, is one of the most difficult problems in nuclear technology. Direct counting of the particles is usually impractical, and measurement must be made through determination of the effects or interaction of the particles in reference materials.

An Analysis of Determinant Factors in the Radiation-Effects Testing of High Polymers—E. G. Fritz, Convair.

The behavior of high-polymer materials in a radiation field depends on a number of nonnuclear factors that are usually neglected in conventional testing. Such neglect may lead to considerable discrepancies in radiation-effects testing of these materials. This paper analyzes the variation of radiation-induced processes as a function of initial molecular weight distribution, molecular architecture, compounding variables, surface-to-volume ratio, and atmospheric environment. Postirradiation phenomena are also discussed. It is further shown to what extent these factors need be considered in developing useful, standardized radiation-effects test procedures.

Irradiation Testing of Enrico Fermi Reactor Prototype Fuel Pins—P. R. Huebner, A. A. Shoudy, and M. A. Silliman, Atomic Power Development Assoc., Inc.

Proof-tests on zirconium-clad uranium-10 per cent molybdenum fuel pins are analyzed to verify the predicted allowable burnup of this alloy, as established from previous capsule irradiation tests on subsized specimens. Tests of full-length pins with burnups ranging from 0.3 to 1.0 a/o (per cent of total metal atoms) have verified predicted high-temperature allowable burnups, but have shown that under certain conditions, excessive swelling could occur at low temperatures.

The pins were individually irradiated in finned capsules cooled by circulating air. Thermocouples at the fin roots provided fuel-pin temperature data. Inlet and outlet air temperatures and air flow rate were continuously monitored to provide for determining fuel-pin heat generation. The advantages of this type of facility lie in its ability to control fuel-pin temperature by controlling air flow, and its provision of accurate pin temperature data.

The Effect of Neutron Irradiation on the Charpy-V and Drop-Weight Test Transition Temperatures of Various Steels and Weld Metals—J. R. Hawthorne and L. E. Steele, U. S. Naval Research Laboratory.

Charpy V-notch and drop-weight specimens were tested after exposure to various nuclear environments to integrated fast-neutron exposures to 1×10^{18} NVT (>1.0 Mev). Integrated fast-neutron flux levels of 5×10^{18} NVT effected 40 to 100 F shifts in transition temperatures. Increasing the irradiation temperature from 200 to 575 F significantly decreased the radiation-induced damage. Transition temperature shifts on the order of 250 F were developed for materials irradiated to 1×10^{18} NVT at temperatures under 200 F. Post-irradiation heat treatment indicated that recovery of properties may be obtained by annealing at 650 F.

Comparison of Charpy V-notch and drop-weight nil-ductility transition-temperature shifts for 17 material irradiations demonstrated excellent correspondence in the evaluation of irradiation effects.

Reactor Spectra Considerations in Radiation-Effects Predictions—John Romanko, Convair.

This paper discusses the state of the art in the specification of reactor differential flux spectra, including neutrons and gammas, with specific comments on the differential flux spectra of a typical light-water-moderated reactor, the Ground Test Reactor. Extensive calculations are made of various radiation effects in materials, including metals, semiconductors, and organics, for various specifications of flux spectra, especially for the neutrons. Examples are given to illustrate the relative importance of the various energy groups of neutrons—for example, in predicting the rate of production of neutron-induced defects in metals and semiconductors. The errors introduced in the calculations when incorrect specifications of flux spectra are used are discussed.

Radiochemistry and Mass-Spectrometry Techniques for Fuel Depletion Studies, WAPD-T-1113—J. E. Hudgens, Jr., Westinghouse Electric Corp.

(Continued in Twenty-second Session)

Nineteenth Session 9:30 a.m.

(Held simultaneously with Eighteenth and Twentieth Sessions)

Session on Fatigue (Continued)

New Observations Relating to the Mechanism of Fatigue Failure—M. A. Wilkov, The Pennsylvania State Univ.

A mechanism of fatigue failure is proposed based upon new observations of the surface changes occurring during cyclic stressing of an annealed steel specimen. The electron microscope in combination with a carbon-platinum replica and a new selected-area technique allowed the observation of the crystallographic events leading to fatigue failure. The observations showed that cavities form on the crystal surface and propagate until adjacent cavities join to form a micro crack. The cavity formation mechanism was dependent upon temperature, and the cavities did not propagate under the action of a static tensile stress. It is concluded that fatigue failure is caused by a stress-motivated diffusion of vacancies produced by the motion of dislocation jogs.

The R. R. Moore Rotating-Beam Fatigue Test—J. R. Gohn and A. Fox, Bell Telephone Laboratories, Inc.

Rotating-beam fatigue tests, using R. R. Moore specimens prepared in accordance with the information given in ASTM Special Technical Publication STP 91, have been used for many years to evaluate the fatigue properties of various materials. The authors' tests indicate that the information given on specimen preparation in this publication is inadequate for fatigue tests on strain-hardenable material such as phosphor bronze rod. Consequently, the rotating beam fatigue tests become a measure of the method used in preparing the test specimen rather than a determination of the fatigue properties of the material. These findings indicate that some revision in the text of STP 91 is required to correct this situation.

Additional Studies of Effect of Anodic Coatings on Fatigue Strength of Aluminum Alloys—G. W. Stickley, Alcoa Research Laboratories.

To supplement an earlier paper, the effects of additional coatings, some as thick as 0.002 in., on the fatigue strength of 7075-T6 are shown. They confirm that thin coatings have no significant effect. Thick coatings, when not sealed, decrease the fatigue strength appreciably;

and sealing may cause further decrease. In the presence of severe stress raisers such as mechanical notches, thick coatings cause no further decrease in fatigue strength. The results of tests of anodically coated alclad sheet of several aluminum alloys are given. The fatigue strengths of such sheet with the thicker anodic coatings generally are lower than those of plain alclad sheet.

The Relationship Between Mechanical Properties Including Hardness and Rolling-Contact Fatigue Life of Several Aircraft Bearing Steels—E. V. Zaretsky and W. J. Anderson, National Aeronautics and Space Administration.

The rolling-contact fatigue life of groups of AISI M-1, AISI M-50, Halmo, and WB-49 alloy steel balls tempered to various hardness levels was determined at room temperature in the fatigue spin rig and the five-ball fatigue tester. A continuous increase in fatigue life and load capacity of each steel was observed with increased ball hardness. These results did not correlate with elastic-limit and yield-strength measurements for bar specimens, which showed optimum values at an intermediate hardness; the results, however, did correlate with resistance to plastic deformation as measured with spherical specimens in rolling contact.

Twentieth Session 9:30 a.m.

(Held simultaneously with Eighteenth and Nineteenth Sessions)

Session on Metals

Long-Time Atmospheric Corrosion Tests of Low-Alloy Steels—H. R. Copson, The International Nickel Co., Inc.

This is the final paper of a series of four published in the ASTM Proceedings. It provides atmospheric corrosion test data on a large group of low-alloy steels exposed for 18 yr at an industrial location at Bayonne, N. J., 17 yr at a marine location at Block Island, R. I., and 15½ yr at a marine location at Kure Beach, N. C. The data show that the better steels develop remarkably protective rust coatings; most of the corrosion of these steels occurs early in the exposure period. This means that moderate thicknesses of the better low-alloy steels will last for exceedingly long times without any protection in severely corrosive atmospheres.

Effects of Alloying Additions on Hot Cracking of Austenitic Chromium-Nickel Stainless Steels—F. C. Hull, Westinghouse Electric Corp.

A quantitative study was made of the effects of various additions on hot cracking of austenitic chromium-nickel stainless steels by means of the cast-pipe tear test. Data are presented for the following elements over a fairly wide concentration range: aluminum, boron, carbon, chromium, cobalt, copper, columbium, hafnium, manganese, molybdenum, nickel, nitrogen, silicon, tantalum, titanium, tungsten, vanadium, and zirconium. The effects of these elements vary widely; some decrease the susceptibility to hot cracking and others are extremely detrimental, even in small amounts. These data provide information for the design of casting or welding-electrode compositions of greatly improved resistance to hot cracking.

Structural Beryllium—B. B. Murdi, Michigan College of Mining and Technology.

An attempt was made to produce beryllium possessing adequate structural characteristics. Specimens of plate beryllium representing five different fabrication methods were compared by metallographic examination, texture analysis, and mechanical tests. The best combination of uniaxial and biaxial properties was exhibited by commercial grade QMV beryllium powder which had been cold compacted and then hot upset. A further advantage of this process over the other four is that it is relatively simple and economical and yields comparatively good surface finish. For upset beryllium, plastic deformation before fracture was appreciable in both tension and flexure—and even under biaxial stress conditions. The fatigue strength, measured by the rotating cantilever beam method, was approximately 45 per cent of the tensile strength at 10^7 cycles.

Mechanical and Physical Properties of Five Copper-Base Casting Alloys—W. H. Johnson and J. G. Kura, Battelle Memorial Institute.

Accurate measurements were made of the mechanical and physical properties of the casting alloys: ASTM B145-52, 5B; B147-52, 8A and 8C; B149-52, 11A; and B198-58, 13B. The common designations of these alloys are 76-2½-6½-15, 65,000 manganese bronze; 110,000 manganese bronze; 20 per cent nickel silver; and 81-4-15 silicon brass, respectively. One objective was to show the properties that could be duplicated by the average brass foundry that employs good practice.

The properties measured, at various temperatures ranging from -40 to 550 F, were ultimate strength, yield strength, elongation, reduction of area, modulus of elasticity, compressive strength, V-notch Charpy impact strength, Brinell hardness, fatigue strength, machinability, melting range, patternmaker's shrinkage, density and specific gravity, electrical resistivity, thermal conductivity, and thermal expansion. These properties were measured on coupons from test-bar castings.

(Continued in Twenty-third Session)

Twenty-first Session**11:15 a.m.****Committee Report Session**

- D-7 on Wood—*L. J. Markwardt, Chairman.*
 D-10 on Shipping Containers—*J. G. Turk, Chairman.*
 D-12 on Soaps and Other Detergents—*J. C. Harris, Chairman.*
 D-13 on Textile Materials—*B. L. Whittier, Chairman.*
 D-14 on Adhesives—*J. E. Rutzler, Jr., Chairman.*
 D-15 on Engine Antifreezes—*R. E. Vogel, Chairman.*
 D-21 on Wax Polishes and Related Material—*W. W. Wallon, Chairman.*
 D-22 on Methods of Atmospheric Sampling and Analysis—*Leslie Silverman, Chairman.*
 E-4 on Metallography—*L. L. Wyman, Chairman.*

Twenty-second Session**2:00 p.m.**

(Held simultaneously with Twenty-third Session)

Symposium on Radiation Effects and Radiation Dosimetry (Continued)**The Effect of Sample Parameters on Energy Absorption from a Neutron Beam.—*R. L. Johnston, Convair.***

A Monte Carlo computer program was used to investigate the effects of specimen size, shape, and composition on the amount of energy lost from a monoenergetic neutron beam incident upon one face of the specimen. The composition calculations confirm that the energy absorbed by compound specimens can be calculated, using a simple additivity assumption, from data obtained for pure-element specimens, provided the pure-element and compound specimens are the same size and shape. The effect of shape was investigated by calculating the energy lost by monoenergetic neutrons in penetrating cylinders of identical mass but varying thickness and radius. These data show that neglect of specimen shape can lead to serious errors in the calculation of energy absorption values.

High-Intensity Gamma-Ray Dosimetry—*D. Hale, D. R. Johnson, S. M. Dec, J. R. Coss, O. Van Sessoms, P. B. Hemmig, and R. E. Brocklehurst, Wright Air Development Div., and W. L. R. Rice, U. S. Atomic Energy Commission.*

Seven dosimetry systems are described. Four are integrated dose systems and three are dose-rate devices. The range of dose or dose rate, spectral sensitivity, and accuracy for each of the systems is discussed. The requirement for approximating the spectral sensitivity, volume, and density of test materials must be considered when the spectrum of the source is unknown or when self-absorption characteristics of the material sample are believed significant. The use of more than one system may be of value for increased reliability or for diagnosing dose-rate or energy-sensitivity effects.

Dosimetry of Mixed γ - n Radiations by Luminescence Degradation—*V. H. Ritz and F. H. Altz, U. S. Naval Research Laboratory.*

Recent publications have shown the feasibility of using the radiation-induced degradation of anthracene and *p*-quaterphenyl as a measure of absorbed dose from gamma-radiation in the range 10^4 to 10^6 rad. The present method uses pressed wafers of these materials, observing the ultraviolet-induced photoluminescence with a fluorimeter.

This luminescence has been shown to originate within a very thin surface layer of the wafer, about 1 micron thick. The absorbed dose given to this surface layer will be strongly influenced by the flux of secondary particles originating in any material placed flat against the surface during exposure to ionizing radiation. For example, if such a material is rich in hydrogen, the recoil protons resulting from fast-neutron collisions will contribute to the absorbed dose. Using graphite instead would remove this contribution. Comparison of such a pair gives a measure of the fast-neutron dose as well as the gamma-ray dose.

Measurements of the Energy Absorbed from Pile Neutrons—*D. Binder, C. D. Bopp, and R. L. Towns, Oak Ridge National Laboratory.*

The energy absorbed by test specimens in a pile may be measured directly by calorimetric methods. In view of the difficulties of in-pile calorimetry, however, it is of interest to develop other methods of measurement. Neutron threshold and resonance reactions provide a means for estimating the neutron spectrum in the pile and may be used to calculate the energy absorbed from neutrons. To test the accuracy of this method, threshold and resonance detectors were placed in various positions in the ORNL graphite reactor and the results were compared with calorimetric measurements. The agreement was within 20 per

cent and was dependent on the neutron spectrum. Chemical systems may be compared with these results to provide other methods for measuring the energy absorbed.

Neutron Dosimetry for Materials Irradiation Studies—*L. E. Steele and J. R. Hawthorne, U. S. Naval Research Laboratory.*

Correct interpretation of radiation effects on materials requires accurate knowledge of neutron exposures. The problems associated with neutron dosimetry for materials-irradiation experiments in research reactors are analyzed, together with neutron flux data as a factor in the experimental environment. Some of the problems discussed are: choosing the best monitors, interpreting preliminary neutron flux surveys, measuring and interpreting flux levels under changing reactor conditions, and using flux data in the analysis of radiation effects. Examples are cited from practical experience in the Argonne CP-5 reactor, the Brookhaven Graphite Reactor, the Oak Ridge Low Intensity Test Reactor, and the Materials Testing Reactor.

Neutron Spectrum Determinations at Low Flux Levels—*Paul Kruger, Nuclear Science and Engineering Corp.*

Low-level neutron flux measurements have been made in several types of neutron-producing irradiation facilities, including radioisotope sources, spent-fuel-element gamma-irradiation facilities, and electron linear accelerators. Neutrons are produced in these facilities by one or more modes of nuclear reaction. The neutron fluxes are generally small, less than 10^4 neutrons per sq cm per sec. To measure low-level neutron fluxes, thick-foil dosimeters or low-level radioactivity counting methods are required. Sensitivities of the order of 0.5 neutrons per sq cm per sec have been achieved. Data are presented for measured thermal, epithermal, and fast-neutron fluxes in several irradiation facilities of each type.

Twenty-third Session**2:00 p.m.**

(Held simultaneously with Twenty-second Session)

Session on Metals (Continued)**Effect of Carbon Content and Melting Practice on the Sharp-Edge-Notch Properties of H-11 and 300M Sheet Steels—*J. L. Shannon, G. B. Espey, A. J. Repko, and W. F. Brown, Jr., National Aeronautics and Space Administration.***

The influence of carbon content and vacuum melting on the room-temperature sharp-edge-notch sensitivity and the fracture toughness of 300M and H-11 steels is described. It is shown that carbon content has a potent influence on the sharp-notch properties. In the case of 300M steel, the highest toughness for a given strength level is obtained with the lowest carbon content necessary to yield that strength level. The opposite effect is noted for the H-11 steel—higher carbon content produces higher notch toughness, particularly for the conditions tempered beyond the maximum of secondary hardening. Improvements in notch toughness were obtained by consumable-electrode vacuum remelting. However, though consistent, these improvements are not large compared with the influence of the carbon content.

Carbon-Strength Relationships in 5 per cent Chromium Ultrahigh-Strength Steels—*J. C. Hamaker and E. J. Valer, Vanadium-Alloys Steel Co.*

The effects of carbon content and vacuum melting on the mechanical properties of 5.0 per cent Cr, 1.3 per cent Mo, 0.5 per cent V ultrahigh-strength steel were investigated between -320 and 1100 F. All compositions exhibited the low annealed hardness, deep air hardenability, and secondary hardening on tempering characteristic of the 0.40 per cent C, 226,000 to 300,000 psi production steel. Vacuum melting markedly improved ductility and toughness, surpassing both carbon content and heat-treated strength level in effectiveness. Two potentially useful new steels were studied: a 0.20 per cent C grade capable of 260,000 psi ultimate with good ductility, hot strength, and weldability; and a 0.50 per cent C grade capable of 330,000 psi ultimate, 275,000 psi yield, with high fatigue and impact strengths. The importance of secondary hardening to the removal of retained austenite and residual stress, for higher fatigue, notch, and transverse properties, is discussed.

Spin Fracture Tests on Ni-Mo-V Generator Rotor Steels in the Brittle Fracture Range—*G. O. Sankey, Westinghouse Electric Corp.*

The brittle fracture behavior of Ni-Mo-V rotor steel is summarized. Five different heat-treated Ni-Mo-V steels having a wide range of mechanical properties were studied by spin testing. A range of specimen sizes were tested to investigate the relationship between rotor notch length and fracture stress. Tests were also made to determine the effects of material transition temperature and ductility. In the latter tests, rotor models were made long enough to insure fracture at or near the condition of plane-strain loading. The effects of notch root radius and of prestressing at an elevated temperature were studied.

Temperature Dependence of the Elastic Moduli of Several Stainless Steels—*Frank Garofalo, U. S. Steel Corp.*

The elastic moduli of two austenitic stainless steels—a Cr-Mn-N steel and a Cr-Mn-V-N steel—and a ferritic stainless steel, modified type 422, were determined between 80 and 1000 F. The elastic moduli and their temperature dependence for the austenitic steels differ in some respects from those found for the standard AISI 300 grades. A measurable difference in behavior is also found for the modified type 422 when compared to a type 410 steel.

Panel Discussion on Low-Cycle Fatigue 3:00 p.m.

This informal session is being sponsored by the Applied Research Panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals. All those interested are invited to attend.

Twenty-fourth Session 4:00 p.m.

(Held Simultaneously with the Twenty-fifth Session)

Committee Report Session

- A-1 on Steel—*J. J. Kanter, Chairman.*
- A-5 on Corrosion of Iron and Steel—*H. F. Hormann, Chairman.*
- B-2 on Non-Ferrous Metals and Alloys—*Bruce W. Gonser, Chairman.*
- B-5 on Copper Alloys, Cast and Wrought—*W. H. Jennings, Chairman.*
- B-6 on Die-Cast Metals and Alloys—*W. Babington, Chairman.*
- E-3 on Chemical Analysis of Metals—*Arba Thomas, Chairman.*
- E-13 on Absorption Spectroscopy—*E. J. Rosenbaum, Chairman.*

Twenty-fifth Session 4:00 p.m.

(Held Simultaneously with the Twenty-fourth Session)

Committee Report Session

- C-7 on Lime—*J. A. Murray, Chairman.*
- C-9 on Concrete and Concrete Aggregates—*W. H. Price, Chairman.*
- C-21 on Ceramic Whitewares and Related Products—*M. D. Burdick, Chairman.*
- D-1 on Paint, Varnish, Lacquer, and Related Products—*W. T. Pearce, Chairman.*
- D-8 on Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses—*H. R. Snoke, Chairman.*
- D-9 on Electrical Insulating Materials—*H. K. Graves, Chairman.*
- D-18 on Soils for Engineering Purposes—*E. J. Kilcawley, Chairman.*
- D-27 on Electrical Insulating Liquids and Gases—*F. M. Clark, Chairman.*
- F-1 on Materials for Electron Tubes and Semiconductor Devices—*S. A. Standing, Chairman.*

Twenty-sixth Session 4:30 p.m.

Marburg Lecture

Solar Energy

Farrington Daniels, University of Wisconsin

The purpose of the Edgar Marburg Lecture is to have described at the annual meetings of the Society, by leaders in their respective fields, outstanding developments in the promotion of knowledge of engineering materials. Established as a means of emphasizing the importance of the function of the Society of promoting knowledge of materials, the Lecture honors and perpetuates the memory of Edgar Marburg, first Secretary of the Society, who placed its work on a firm foundation and through his development of the technical programs brought wide recognition to the Society as a forum for the discussion of properties and tests of engineering materials. [See abstract on p. 10.]

Charles B. Dudley Medal Award Sam Tour Award
Richard L. Templin Award

THURSDAY, JUNE 30

Twenty-seventh Session 9:30 a.m.

(Held simultaneously with Twenty-eighth Session)

Symposium on Low-Temperature Properties of High-Strength Aircraft and Missile Materials

Owing to the increasing use of cryogenic propellants such as liquid oxygen and liquid hydrogen in missiles and space vehicles, the properties of high-strength structural materials at extremely low temperatures are becoming of prime importance. The papers in this symposium will consider the mechanical properties of promising high-strength structural alloys at temperatures ranging down to -423°F . In order to obtain optimum strength: density ratios, most of the alloys reported in this symposium were either heat treated or cold worked to their highest strength levels commensurate with adequate toughness.

Since this symposium is aimed primarily at missile and space vehicle applications, attention was focused on sheet alloys. Also since weldability is of major importance in the fabrication of these vehicles, data pertaining to the low-temperature properties of welded joints in these alloys are reported. Finally, since toughness is of increasing importance where high-strength alloys are used at high stress levels and low temperature, data measuring resistance to brittle fracture are reported wherever possible.

Sharp-Notch Behavior of Some High-Strength Aluminum Sheet Alloys and Welded Joints at 75, -320 and -423°F —*M. P. Hanson and H. T. Richards, National Aeronautics and Space Administration, and G. W. Stickley, Alcoa Research Laboratories.*

The notch tensile characteristics of several high-strength sheet aluminum alloys, with and without welds, were determined at room temperature, -320 and -423°F . Alloys investigated were 2014-T6, 2219-T62, 5456-H321, 6061-T6, 7075-T6, 7079-T6, and 7178-T6 sheet in the longitudinal and transverse directions. Tests were made using smooth specimens and specimens with sharp edge notches. All welds were made in inert gas, using weld wire compositions suitable for the respective sheet alloys. The various alloys are compared.

Some Low-Temperature Properties of Aluminum-Alloy Weldments—*W. R. Lucas and C. E. Cataldo, Redstone Arsenal.*

The tensile properties of weldments in five aluminum alloys—5052, 5086, 5456, 2014-T3, and 2014-T6—were studied at temperatures from ambient to -320°F . The behavior of weldments is compared with that of the wrought alloys. The observed effects of welding process, welding variables, filler material, and weld bead configuration on low-temperature behavior are reported. It is shown that the properties of the wrought material cannot be extrapolated to the weldment and that the behavior of weldments is not understood sufficiently to allow prediction of their low-temperature behavior. Thus, testing of aluminum-alloy weldments under anticipated use conditions is still required. The test equipment is described and its accuracy is discussed.

The Use of Aluminum Alloys for Missile Structural Applications at Cryogenic Temperatures—*R. Masteller, Martin-Denver.*

The paper discusses the use of aluminum alloys in missile structural applications at cryogenic temperatures with particular emphasis on 2014-T6. The principle points discussed are: (1) Properties of 2014-T6 at room and cryogenic temperatures, (2) Limitations of 2014-T6 in cryogenic applications, (3) The uses of other aluminum alloys such as 6061 and 5456 for cryogenic applications, and (4) Problems encountered in welding 2014-T6 aluminum alloy. Discussion is based on the use of these materials at liquid nitrogen-liquid oxygen temperatures. Conjecture supported by some test data is presented on the use of these materials at liquid hydrogen temperatures.

Thermal Cycling Under Constant Stress to Low Temperatures of Aluminum and Magnesium Alloys—*Volker Weiss, George Sachs, G. T. Schaeffer, and A. Saule, Syracuse Univ.*

The effect of thermal cycling under constant stress of aluminum and magnesium alloys was investigated for sawtooth-type thermal cycling. Creep and creep rupture occurred on cycling at all temperatures. The data are compared with conventional creep, stress-rupture, and intermittent-creep concepts. The ratio of the "average creep rate" in these tests to that of isothermal tests at the maximum temperature was not constant, but depended upon other variables investigated. For a given number of cycles to failure the stress required decreased with maximum cycle temperature approximately proportional to the isothermal creep stress. The effect of heating rate on the number of cycles to failure was small. The expected increase in number of cycles with increasing heating rate was not always observed.

(Continued in Thirtieth and Thirty-second Sessions)

Twenty-eighth Session 9:30 a.m.

(Held simultaneously with Twenty-seventh Session)

Session on General Testing

A Method for Determining the Impact Sensitivity Characteristics of Materials with Highly Reactive Oxidizers—*R. Kopituk, Thiokol Chemical Corp.*

The need for higher-performance rocket propellants has resulted in a wide variety of propellants which in many cases are highly reactive, not only with other propellants, but also with metal, ceramic, plastic,

THURSDAY, JUNE 30 (Continued)

and liquid materials used in construction or operation of the rocket engine or missile. Materials that come in contact with propellants are tested for compatibility; one of the latest tests of this type is the impact detonability test. This paper describes one of the latest techniques used in impact testing. The paper includes the history of equipment development, a detailed description of the critical parts, data accumulated with the new tester, and a set of materials for correlating data between different testers.

Shock Testing of Ground-Support Equipment and Industrial Items Weighing from 1000 to 50,000 Pounds—W. H. Grumet, American Laboratories.

A brief history of the origin of American Laboratories' horizontal shock tower is presented, with a discussion of typical difficulties encountered pertaining to specification analysis and establishment of industry-wide acceptable test standards, procedures techniques, and analysis of test results. The tower is described in detail. Also included are methods for obtaining and controlling various shock amplitudes and duration, as well as an over-all discussion of acceptable instrumentation. Discussion of general application and benefits of the shock tower is illustrated by specific test programs: MIL-A-8421 Air Transportability testing, railroad humping, package design evaluation, cargo carrier certification, and zone C testing for Silo missile hard site.

Flow Properties of Bulk Solids—A. W. Jenike, P. J. Elsey, and R. H. Woolley, University of Utah.

The Jenike-Shield concept of a variable yield function for Coulomb solids is adapted to real materials, and properties which determine the flow-ability of bulk solids are developed. It is shown that, during plastic flow, bulk solids can be either work-hardening or work-softening, depending on the direction of change of the major pressure. A direct-shear testing machine and a consolidating bench which have been developed to measure the flow properties are described in detail. The method of testing is also fully described.

Mathematical Interpretation of Experimental Data—W. J. Worley, University of Illinois.

This paper discusses numerous power function equations that may be useful in analyzing experimental data and interprets the equations in terms of graphical plots. The plots include linear, log-linear, log-log, log(log)-linear, log(log)-log, log(log)-log(log) coordinates, to achieve linearization of the results. The equations corresponding to the various linearized plots are presented in tabular form. A log-log procedure for obtaining essentially linear plots of sine and cosine functions is presented. Commercially available graph papers are discussed. A procedure for creating the desired type of coordinate scale is given. Graphs are presented which illustrate the effects of plotting various types of data using the coordinate system which linearizes the data as contrasted with plots which do not linearize the same data.

Papers on Effect of Nuclear Bombardment on Rubber Materials 9:30 a.m.

This informal session is being sponsored by Committee D-11 on Rubber and Rubber-Like Materials. All those interested are invited to attend.

Twenty-ninth Session 11:15 a.m.

Committee Report Session

- C-3 on Chemical-Resistant Mortars—J. R. Allen, Chairman.
- C-13 on Concrete Pipe—R. R. Litchner, Chairman.
- C-14 on Glass and Glass Products—L. G. Ghering, Chairman.
- C-16 on Thermal Insulating Materials—W. C. Lewis, Chairman.
- C-22 on Porcelain Enamel—W. N. Harrison, Chairman.
- E-1 on Methods of Testing—A. C. Webber, Chairman.
- E-6 on Methods of Testing Building Constructions—R. F. Leggett, Chairman.

Max Hecht Award

To be presented at the Committee D-19 Luncheon at 12 noon.

Thirtieth Session 2:30 p.m.

Symposium on Low-Temperature Properties of High-Strength Aircraft and Missile Materials (Continued)

Low-Temperature Mechanical Properties of Wrought and Cast Magnesium Alloys—R. W. Fenn, Jr., Dow Metal Products Co.

Tensile properties at temperatures of 75, -109, and -321 F are reviewed for: AZ31B-H24, HK31A-H24, HK31A-O, HM21A-T8, ZE10A-O, ZE10A-H24, and ZE41XA-H24 magnesium sheet alloys in the welded and unwelded conditions. New tensile data obtained at 75, -109, and -321 F are presented for: extruded HM31A-T5 and (PZ)ZE62X1-T5 (both welded and unwelded), and cast AZ91C-T6, AZ92A-T6, EZ33A-T5, HK31A-T6, QE22A-T6, and ZH-62A-T5 magnesium alloys. Notched and unnotched low-temperature Charpy impact strengths of the cast alloys are compared.

Some Mechanical Properties of Magnesium Alloys at Low Temperatures—R. P. Reed, R. P. Mikesell, and R. L. Greeson, National Bureau of Standards.

Unnotched tensile tests and Charpy V-notch impact tests were conducted on six magnesium alloys at four temperatures: 300, 195, 76, and 20 K. The magnesium alloys tested were wrought AZ31B-O, ZE10A-H11, HM21A-T8, and HK31A-O; extruded HM31A-F; and sand-cast HK31A-T6. The alloys generally increased in tensile strength, decreased in tensile elongation, and decreased in impact strength with a decrease in temperature. Both macroscopic and microscopic pictures were taken to indicate deformation and fracture characteristics.

Sharp-Edge-Notch Tensile Characteristics of Several High-Strength Titanium Sheet Alloys at Room and Cryogenic Temperatures—G. B. Espey, M. H. Jones, and W. F. Brown, Jr., National Aeronautics and Space Administration.

The paper presents information relating to the behavior of high-strength titanium sheet alloys in the presence of very high stress concentrations. Sharp-edge-notch tension specimens of the design recommended by the ASTM Committee on Fracture Testing of High Strength Sheet Materials were used to determine the relative sharp-notch sensitivity of several titanium alloys at room temperature, -320, and -423 F. In addition, the titanium alloys are compared with several high-strength sheet steels of current interest to the missile and rocket industry.

Materials for Use at Liquid-Hydrogen Temperatures—J. H. Belton, L. L. Godby, and B. L. Taft, Pratt and Whitney Aircraft Div.

This paper covers the procedures and techniques for tensile and expansion-coefficient testing of materials at liquid-hydrogen temperature (-423 F) and includes a description of testing chambers. Tensile properties and coefficients of linear expansion at liquid-hydrogen temperatures and other temperatures for comparison are presented for materials applicable to rocket engines, including aluminum, nickel, iron, copper, and titanium-base alloys and plastics. Materials and their physical properties are discussed in relation to design of rocket engine components subjected to low temperatures.

Effect of Stress Concentration on the Tensile Strength of Titanium and Steel-Sheet Alloys—George Sachs and J. G. Sessler, Syracuse Univ.

The effects of stress concentrations in edge-notched sheet specimens were studied for a number of ultrahigh-strength steels and heat-treated titanium alloys at various test temperatures. In addition, a titanium alloy heat treated to a completely brittle condition was investigated. The test results illustrate the wide variations in the behavior of different alloys at different temperatures. It appears that some steels approach a completely brittle condition at very low temperatures. The brittle conditions exhibit a behavior that conforms with the present concept of brittle materials.

(Continued in Thirty-second Session)

Thirty-first Session 4:30 p.m.

Committee Report Session

- A-3 on Cast Iron—T. E. Eagan, Chairman.
- D-5 on Coal and Coke—O. W. Rees, Chairman.
- D-6 on Paper and Paper Products—R. H. Carter, Chairman.
- D-23 on Cellulose and Cellulose Derivatives—F. A. Simmonds, Chairman.
- D-25 on Casein and Similar Protein Materials—H. W. Shader, Chairman.
- D-26 on Halogenated Organic Solvents—V. E. Amspacher, Chairman.
- E-10 on Radioisotopes and Radiation Effects—C. E. Webber, Chairman.
- E-12 on Appearance—G. W. Ingle, Chairman.

Thirty-second Session 8:00 p.m.

(Held simultaneously with Thirty-third and Thirty-fourth Sessions)

Symposium on Low-Temperature Properties of High-Strength Aircraft and Missile Materials (Continued)

Effect of Low-Temperature Rolling on 300 Series Stainless Steel—*C. R. Mayne, The International Nickel Co., Inc.*

Properties of the Precipitation-Hardening Stainless Steels and Low-Alloy High Strength Steels at Very Low Temperatures—*J. E. Campbell and L. P. Rice, Battelle Memorial Institute.*

Results of tension tests on AM-350, 17-7PH, PH 15-7Mo, AISI 4340, 300-M, and Vascojet 1000 steels are presented over the temperature range from room temperature to -423°F . The data were obtained on standard unnotched specimens and specimens containing notches producing a stress concentration factor of three. The low-temperature properties of these steels are compared with the properties of austenitic stainless steels, nickel alloys, titanium alloys, and aluminum alloys on a strength-weight basis. Several examples are also discussed to show that treatments that produce optimum properties for room-temperature service do not provide optimum properties for low-temperature service.

Low-Temperature Properties of Cold-Rolled AISI Types 301, 302, 304ELC, and 310 Stainless-Steel Sheet—*J. P. Watson and J. L. Christian, Convair-Astronautics.*

The mechanical properties of a series of cold-rolled austenitic stainless steels were determined at 78, -100 , -320 , and -423°F , and for a number of different tempers. In addition, the notched/unnotched tensile ratios (stress concentration factor $K_t = 6.3$), and tensile strengths of heliarc butt-welded joints of these alloys were obtained at the same temperatures.

Both the mechanical properties and toughness (as measured by notched/unnotched tensile ratios) were found to be strongly dependent upon the austenite-to-martensite reaction which occurred in some of these steels under the combined influence of low temperature and high tensile stress. The effect of microstructure on properties was studied by metallography, X-ray diffraction, and magnetic measurements.

The Effect of Carbon Content on the Notch Properties of 43XX-Vanadium Modified and 5 per cent Chromium Sheet Steels—*E. P. Klier, Catholic University of America.*

The notch properties of 43XX-vanadium modified steel containing 0.20, 0.30, 0.40, 0.50 and 0.60 per cent carbon were measured for several tempered conditions at temperatures from -320 to 85°F . Also tested were 5 per cent Cr steels containing 0.24 and 0.39 per cent carbon heat treated to hardnesses from 40 to 50 Rockwell C. In the 43XX-V modified steels, reduced carbon content increased notch toughness. In the 5 per cent Cr steels, the reverse effect was observed. The fracture characteristics of the steels are discussed at length.

Summary—*A. Hurlich, Convair-Astronautics.*

Thirty-third Session

8:00 p.m.

(Held simultaneously with Thirty-second and Thirty-fourth Sessions)

Session on Road and Paving Materials

Stress-Deformation Characteristics of Sand Bituminous Mixtures—*J. A. Carpenter, Standard Oil Company of California.*

Triaxial compression tests were made on specimens of fine uniform sand before and after stabilization with bituminous binders, to obtain basic shearing strength of sand and sand-bituminous mixtures at varying initial void ratios. Specimens were tested at two different strain rates. A technique for obtaining the Mohr rupture envelope using one test specimen is described. Results are analyzed for: (1) the effect of initial density on the peak and ultimate strength of cohesionless soils, (2) the merits of an open triaxial test procedure in which the stress conditions are varied during testing in order to obtain the Mohr rupture envelope using one test specimen, and (3) the effects of bituminous binder addition and of strain rate on the shearing-strength characteristics of sand-bituminous mixtures.

The Effect of Compaction Temperature on the Properties of Bituminous Concrete—*R. W. Kiefer, Cornell Univ.*

Laboratory tests were performed on specimens of bituminous concrete surface course mix compacted by means of the Hvem kneading compactor at six compaction temperatures ranging from 150 to 350°F . The differences in specific gravity, per cent voids, stabilometer value, angle of internal friction, cohesion value, and apparent cohesion of the mix which resulted from the compaction at these six different temperatures are plotted and discussed. The test results have applications to laboratory compaction studies using the kneading compactor and to the testing of suitability of mixes against established specifications.

A Method for Measuring Air Permeabilities of Asphalt Concrete Pavements—*W. H. Ellis, California Research Corp.*

A new method for measuring the air permeabilities of asphalt concrete pavements is presented. The equipment and its operation are described in detail. The apparatus consists of a volumetrically-calibrated

glass reservoir, a 4-in. diameter glass dome, sealing material, a sensitive manometer, and a stop watch. A falling head of water is used to maintain a small, constant pressure drop through the pavement. Measurement of the water flow rate gives the air flow rate through the pavement. Determinations can be made on pavements in place or on cores in the laboratory. Data are given showing the repeatability of the method. The uniformity of typical pavements as shown by variations in permeability are also discussed. Permeability profiles are included which show how permeability changes with depth below the surface.

The Influence of Asphalt Composition on Its Rheology—*R. S. Winniford, California Research Corp.*

Basic flow properties of asphalt are reviewed. Newtonian and non-Newtonian flow, thixotropy, elasticity, and temperature susceptibility of asphalts are discussed.

Microviscometer measurements on paving and industrial asphalts and on synthetic asphalts compounded from asphalt fractions show that asphalt viscosity is primarily dependent on asphaltene content, but that asphaltene chemistry is an important variable. Thixotropy is related to the state of dispersion of the asphaltenes and is strongly influenced by the viscosity of the system. Non-Newtonian character is related principally to the paraffinicity of the asphaltenes. The temperature susceptibility of asphalts is governed to a first approximation by the temperature susceptibility of the maltenes. In the temperature range from 115 to 180°F , the asphalts are more highly thixotropic than at 77°F .

Emulsified Asphalt Tests and Specifications—*K. E. McConaughay, K. E. McConaughay, Inc.*

Emulsified asphalts for roads must be suited to the widely varying types of construction in which they are used. Data are presented to show that present specifications for emulsified asphalts, in which classification is based on empirical tests not related to construction, are inadequate to serve the needs indicated by this variety of uses. Tests are proposed of a functional or simulated service nature, and data from them are shown to provide a basis for realistic and meaningful specifications. Specifications based on such concepts are presented and their meaning with respect to ionic classification of asphalt emulsions is discussed.

Laboratory Tests and Recommended Specifications for Rapid-Setting and Coarse-Mixing Cationic Asphalt Emulsions—*E. W. Mertens, L. D. Coyne, and E. D. Rogers, California Research Corp.*

ASTM tests and product specifications are not available for the relatively new cationic asphalt emulsions. These are needed to insure product quality and uniformity and to give some indication of field performance. This paper presents a series of tests found useful in evaluating cationic asphalt emulsions. Included are product quality tests, such as residue, sieve, and viscosity, and functional tests indicative of field performance, such as the stone-coating-water-resistance test. Modifications of existing ASTM tests and completely new tests are described in detail with supporting test data. Product specifications are recommended for cationic emulsions. New specifications which have no counterpart in the anionic emulsion systems are the pH requirement, the particle charge test, and the performance tests.

Thirty-fourth Session

8:00 p.m.

(Held simultaneously with Thirty-second and Thirty-third Sessions)

Session on Cement and Plaster

The Reproducibility of Tests for Determining the Strength of Portland Cement—*M. F. Kaplan, South African Council for Scientific and Industrial Research.*

A study was made of the "within-batch," "batch-to-batch," and "between-operator" reproducibility of flexural and modified cube compression tests on hand-mixed and compacted mortar specimens. The results of more than 2000 tests are compared with those of the CEMBUROU tests, in which the mortar test specimens are mechanically mixed and molded, the British Standard compression tests on concrete and vibrated mortar cubes, and the ASTM Method of Test for Compressive Strength of Hydraulic Cement Mortars.

An X-Ray Diffraction Investigation of Hydrated Portland-Cement Pastes—*D. L. Kuntro, L. E. Copeland, and Elaine R. Anderson, Portland Cement Assn.*

X-ray diffraction data were obtained from a group of well-hydrated portland cement pastes. Thin slices of saturated hardened pastes were observed and the results compared with those obtained from samples of the same material ground and thoroughly dried. Data were also obtained from samples of dried pastes which had been brought to equilibrium at several relative humidities between 7 and 100 per cent.

An Improved Method for the Determination of the Normal Consistency of Plasters—*R. A. Kuntze, Ontario Research Foundation.*

A modification of the ASTM method C 26-56 for the determination of the normal consistency of plasters, which employs a conical instead of a cylindrical plunger, is described. With this apparatus a linear relationship exists over a wide range between the penetration of the

THURSDAY JUNE 30 (Continued)

conical plunger and the water:stucco ratio of the plaster, so that the normal consistency can be estimated from a single test.

Experiments with cones of different apex angles and weights and with different stuccos are discussed. Results indicate that the slope constant is dependent on the apex angle of the cone and is independent of the type of stucco. The method appears to be an improvement over others, for which simple relationships are absent.

FRIDAY, JULY 1

Thirty-fifth Session

9:30 a.m.

Symposium on Quality of Observations

The purpose of this symposium, jointly sponsored by the Administrative Committee on Research and Committee E-11 on Quality Control of Materials, is to discuss some fundamental problems in the interpretation of measurements.

There are two aspects to a test result: the first concerns the actual magnitude obtained, and the second concerns the quality of the observed result. The quality of a result is often given by statements about the precision and accuracy. The evaluation of the precision and accuracy requires a collection of test results obtained under conditions encountered in practice. The papers in this session are directed to making clear the meanings of these terms and to a survey of methods that can be used to determine precision and accuracy.

On the Meaning of Precision and Accuracy—R. B. Murphy, *Bell Telephone Laboratories Inc.*,

Precision and accuracy are important statistical features of any measurement process. In the past few years there has been much discussion as to how these terms should be used. Committee E-11 on Quality Control of Materials has worked on this problem of definitions in an effort to (1) provide meanings of the terms "precision" and "accuracy" which are acceptable and useful to ASTM members, and (2) provide a common frame of reference for the various measures of precision and accuracy used in different fields of testing materials. The paper will tell how the present recommendations were arrived at.

How to Evaluate Precision—W. S. Connor, *Research Triangle Inst.*

Precision concerns the agreement among independent observations taken under conditions that are as much alike as possible. Precision may be evaluated from such repeated observations, or it may be evaluated indirectly from observations taken under different conditions. Such indirect assessments of precision may be more correct than direct assessments. These ideas will be illustrated by data from experience.

How to Evaluate Accuracy—W. J. Youden, *National Bureau of Standards.*

This paper presents a logical breakdown of the error in a measurement into (1) the systematic error inherent in the procedure, (2) the local systematic error of the laboratory using the procedure, and (3) the random error (precision). This breakdown should facilitate efforts

to attain better accuracy. Several methods are given for identifying sources of error in measurements.

Residuals—An Analytical Tool—Milton Terry, *Bell Telephone Laboratories, Inc.*

As an experimentalist goes from data taking to data analysis his scientific attitude changes to that of a theorist in the following sense: Given a set of experimental data, he poses a hypothesis regarding the fundamental structure and goes about estimating the defining parameters of the structure and testing the hypothesis he has formulated under the assumption he is willing to accept. Some experienced experimenters also want techniques for gathering evidence from the data as to its internal consistency, validity, and conformity with the underlying assumptions used in testing and estimation. A set of statistics, residuals, are defined and used in a variety of ways to meet this criterion.

Thirty-sixth Session

12:30 p.m.

(Held Simultaneously with Thirty-seventh Session)

Committee Report Session

D-2 on Petroleum Products and Lubricants—Harold M. Smith, *Chairman.*

D-4 on Road and Paving Materials—A. B. Cornthwaite, *Chairman.*

D-11 on Rubber and Rubber-Like Materials—Simon Collier, *Chairman.*

D-16 on Industrial Aromatic Hydrocarbons and Related Materials—W. E. Sisco, *Chairman.*

D-17 on Naval Stores—S. R. Snider, *Chairman.*

D-19 on Industrial Water—Max Hecht, *Chairman.*

D-20 on Plastics—F. W. Reinhart, *Chairman.*

D-24 on Carbon Black—N. P. Bekema, *Chairman.*

E-11 on Quality Control of Materials—S. Collier, *Chairman.*

Thirty-seventh Session

12:30 p.m.

(Held Simultaneously with Thirty-sixth Session)

Committee Report Session

B-7 on Light Metals and Alloys, Cast and Wrought—R. A. Harris, *Chairman.*

C-1 on Cement—R. R. Litehiser, *Chairman.*

C-11 on Gypsum—G. W. Josephson, *Chairman.*

C-15 on Manufactured Masonry Units—J. W. Whittemore, *Chairman.*

E-2 on Emission Spectroscopy—D. L. Fry, *Chairman.*

E-5 on Fire Tests of Materials and Construction—W. J. Krefeld, *Chairman.*

E-7 on Nondestructive Testing—J. H. Bly, *Chairman.*

E-14 on Mass Spectrometry—R. A. Friedel, *Chairman.*

E-15 on Analysis and Testing of Industrial Chemicals—W. A. Kirklin, *Chairman.*

Actions on Standards

THE ADMINISTRATIVE COMMITTEE ON STANDARDS is empowered to pass on proposed new tentatives and revisions of existing tentatives, and tentative revisions of standards offered between Annual Meetings of the Society. On the dates indicated the Standards Committee took the following actions. Anyone interested in securing copies of the standards should write to Headquarters regarding their availability.

Thermal Insulating Materials

Tentative Specifications for Mineral-Wool Hydraulic-Setting Thermal Insulating and Finishing Cement (C 449 - 60 T)

New Tentative (Accepted Feb. 29, 1960)—These specifications cover the composition and physical properties of mineral-wool insulating and finishing cement, shipped in dry-mix form, including hydraulic-setting binder, which when

mixed with water and applied in accordance with the manufacturer's directions affords a smooth surface as a final finish for heated surfaces up to 1200 F.

Rubber and Rubber-Like Materials

Tentative Methods of Testing Hard Rubber Products (D 530 - 59 T)

Revision (Accepted March 3, 1960)—The test methods have been clarified, and new procedures have been added covering rupture resistance and distention, and an alternate method for hardness using the Shore D durometer.

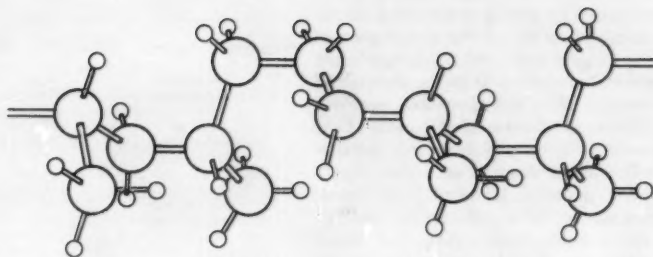
Tentative Methods of Testing Asphalt Composition Battery Containers (D 639 - 57 T)

Revision (Accepted March 3, 1960)—The methods have been completely rewritten and expanded to cover battery containers made from hard rubber and equivalent materials.

Tentative Recommended Practice for Description of Types of Styrene-Butadiene Rubbers (SBR) (D 1419 - 59 T)

Revision (Accepted March 3, 1960)—The recommended practice has been expanded to cover also butadiene rubbers (BR), and numbers for three new synthetic rubbers have been assigned.

New Polymers— New Problems¹

By H. F. MARK²

I should like to focus attention on a group of substances, well known in general terms, which play a very important role in the work of many of our committees and which are, in fact, rather frequently a headache in our deliberations and experiments because of the unusually rapid development which is characteristic of them today. I am referring to polymers in the broadest sense of the word—natural and synthetic, purely “organic” or partly “inorganic.” These materials are of great fundamental importance because they force us to develop new methods for their synthesis and characterization, methods which will eventually enable us to elucidate fully the structure of proteins and with it the nature of life. However, polymers are also of immediate practical interest because they furnish an entire spectrum of indispensable materials such as films and fibers, plastics and rubbers, or coatings and adhesives.

General Properties:

From this practical point of view the search for new polymers intends to improve their mechanical and thermal properties and to extend the range of their serviceability. In order to establish the present position, it will be useful to review a number of figures which characterize the order of magnitude of the various properties of materials that are used for the construction of buildings, vehicles, machines, and articles of daily use.

Table I compares the moduli of rigidity (Young's moduli) of a few representative metals and ceramics with those of the most important organic and inorgano-organic polymers. It can be seen that polymers are, in general, very much softer than the other materials, although the hardest plastics now approach the softest metals. It is also significant that the rigidity range of the soft and supple building materials is distinctly wider than that of the hard and brittle substances. This evidently stimulates the

question: How could one make still harder polymers in order to enrich the spectrum of useful building materials and to produce a substantial overlapping of the two groups rather than to have a gap between them? It will be the object of this lecture to enumerate and appraise the existing methods that can lead to such a goal.

A comparison of the same character is presented in Table I where the tensile properties—strength and elongation at break—are listed for the same groups of representative materials. Again a significant difference becomes evident: the strength of metals and ceramics is, on the average, 20 times larger than that of polymers, but their elongation to break is correspondingly smaller. However the strongest fibers are substantially superior to the weakest metals, and there exists no gap here between the two groups of representative building materials. If one is interested in the total work that has to be expended in order to sever a piece of any of these materials, it must be remembered that this is a function of the product of the strength and the elongation to break. Considering this product, it becomes evident that rubber-like organic polymers are the toughest materials, a conclusion that is well supported by the fact that such substances are used in automobile and airplane tires, in transport belts, and shoe soles. A closer study of the table again stimulates questions such as: How could one increase the elongation to break of a metal without reducing its strength too much? Or: Would it be possible to increase the strength of a rubber without losing too much elongation at

break? Such a discussion will be the subject of a later paragraph.

Another important property is the weight of a building material per unit of volume. Table I therefore lists the specific gravities of representative numbers of the two groups and makes it immediately evident that polymers are always lighter, and in some cases very much lighter than metals or ceramics. In the case of a very strong metal such as tungsten and a very strong fiber such as nylon the ratio of the strength to weight is in favor of nylon. Hence in terms of providing the strongest connections per pound of material used the organic polymers are on top of the list of all existing substances.

Passing from the purely mechanical properties to the thermal behavior, the most important figure is the temperature at which a material begins to soften. On this count, metals and ceramics are distinctly superior and it is not even necessary to present a special table because everybody knows that even the melting points of the low melting structural metals such as aluminum and brass are several hundred degrees above the softening ranges of all presently known polymers. Evidently again a problem for research presents itself: How can one make plastics that will have substantially higher softening ranges and be more resistant to chemical decomposition at elevated temperatures?

Considering first the specific gravity, it is clear that one should use for the construction of the polymer molecules only elements of low atomic weights. In view of high melting characteristics and great mechanical strength, we

TABLE I.—PROPERTIES OF REPRESENTATIVE MATERIALS.

Material	Young's Modulus, psi	Tensile Strength, psi	Elongation, per cent	Specific Gravity, g per ml
Tungsten.....	50 × 10 ⁶	600,000	4	18.5
Steel.....	30	300,000	5	7.8
Brass.....	15	120,000	5	8.4
Duraluminum.....	12	80,000	6	2.5
Quartz.....	45	700,000	1.5	2.6
Ceramics.....	25	200,000	1.5	2.7
Polyolefins.....	0.2	6,000	80	0.88 to 0.98
Celluloses.....	0.4	12,000	15	1.3 to 1.5
Vinyls (including polystyrene).....	0.4 to 1.2	15,000	15	1.1 to 1.5
Thermoset plastics.....	5	20,000	1.5	1.2 to 1.6
Organo-inorganic plastics.....	8	25,000	2	1.4 to 1.8
Glass-fiber reinforced plastics.....	15	30,000	3	1.8 to 2.0

¹ Presented at the Sixty-second Annual Meeting of the Society, June 23, 1959, Atlantic City, N. J.

² Director, Polymer Research Institute, Polytechnic Institute of Brooklyn.

should expect that such properties will be favored by strong bonds between the individual atoms of the molecules and by a large number of these bonds per unit volume, that is by a high bond density. Here again we can conclude that elements of the first period of the system will be advantageous because their volume is small and, as a consequence, dense packing with many bonds per unit volume is possible. Crystalline boron, carbon (diamond), and boron nitride are, in fact, very hard, very strong, and very high-melting solids which would be very interesting building materials if they could be readily obtained in larger pieces of controlled shape. Many strong chemical bonds exist in these materials in all directions of space and produce systems that are so difficult to deform and to melt that they become practically intractable for such forming processes as spinning,

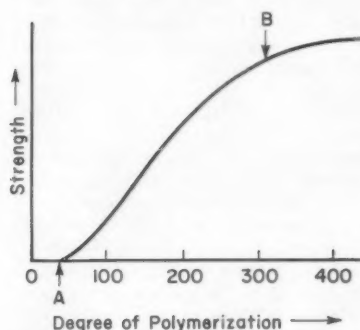


Fig. 1.—Influence of the degree of polymerization on mechanical properties.

casting, molding, or extruding. For the benefit of tractability and for the development of a reasonably large deformation to failure, such as elongation to break, it is apparently necessary to think of a compromise between firmness and deformability that can be controlled by the proper molecular and supermolecular architecture of the system. One successful way to arrive at many very useful compromises of this type is the use of linear macromolecules inside of which there exist strong chemical bonds of the same character and strength as in diamond, quartz, or aluminum oxide. Between the chains of such a system there are established attractive forces the nature and frequency of which determines the position of any particular material in the spectrum of thermal and mechanical properties. Many years of theoretical and experimental efforts have established certain principles which control the relationships between structure and behavior and are welcome not only for the understanding of facts and correlations which are already known but, most of all, offer extremely interesting suggestions whenever one attempts to

TABLE II.—ENERGIES OF COHESION ALONG AND ACROSS LINEAR POLYMER MOLECULES.

Polymeric Substance	Bond Along the Chain	Strength of Bond Along the Chain, kcal per mole	Unit Responsible for Intermolecular Attraction	Inter-molecular Attraction, cal per mole
Polyethylene.....	C—C—	70 to 80	2(CH ₂)	1000
Polyisobutylene.....	C—C—	70 to 80	3(CH ₂), CH ₃	1200
Polybutadiene.....	C=C—	70 to 120	2(CH ₂), (CH=CH)	1100
Rubber.....	C=C—	70 to 120	2(CH ₂), (CH=C·CH ₂)	1300
Polystyrene.....	C—C—	70 to 80	2(CH ₂), (C ₆ H ₅)	4000
Polychloroprene.....	C=C—	70 to 120	2(CH ₂), (CH=CCl)	1600
Poly(vinyl chloride).....	C—C—	70 to 80	(CH ₂), (CHCl)	2600
Poly(vinyl acetate).....	C—C—	70 to 80	(CH ₂), (COOCH ₃)	3200
Poly(vinyl alcohol).....	C—C—	70 to 80	(CH ₂), (CHOH)	4200
Cellulose.....	C—O—C—	80 to 90	3(OH), 2(—O—)	6200
Cellulose acetate.....	C—O—C—	80 to 90	3(OOCCH ₃), 2(—O—)	4800
Polyamides.....	C—N—C—	70 to 90	10(CH ₂), 2(CONH)H	5800
Silk fibroin.....	C—N—C—	70 to 90	(CHR), (CONH)H	9800

arrive at new materials with a more favorable compromise of behavior.

We shall now enumerate and discuss the most important of these principles and see how they can be used—and have already been used—to prepare polymers with high resistance against elevated temperatures and, at the same time, with reasonable tractability.

Molecular Weight:

One factor of great importance is the molecular weight of a polymer which is often, for simplicity, expressed in terms of the degree of polymerization (DP), that is, the average number of monomers that are linked together in the macromolecular chains. Extensive tests with many polymeric substances have shown that there exists, for all of them, a characteristic relationship between mechanical strength and DP, which is diagrammatically presented in Fig. 1. It shows that in each case there exists a threshold value, *A*, below which no mechanical resistance is displayed. This critical DP is different for different polymers but, in general, it can be said that materials with DP's below 50 are still either viscous liquids or waxy masses or friable powders. Above the threshold value there exists a DP range within which one encounters a rapid development of practically all valuable mechanical properties. On the ordinate of Fig. 1 there can be plotted tensile, bending, folding, or impact strength or even more complicated quantities such as abrasive resistance or endurance in flexure testing, the exact shape of the curve changes from one to the other but its general character remains essentially unaffected. These conditions of favorable response continue for a while, until, again with a more or less sharp break *B*, a domain of diminishing return is reached within which there is still some gain in properties with increasing DP but much less pronounced than before. The position of the second turning point varies with the polymer under consideration and with the quantity plotted on the ordinate but, in

general, is somewhere between 350 and 550.

For everyone who attempts to develop a new polymer, the existence of a curve of the type of Fig. 1 evidently is of considerable value, because if he arrives at the conclusion that the DP of his material is still closer to *A* than to *B* his efforts will primarily be directed to an increase of the molecular weight of his polymer. On the other hand, if there are indications that the DP of his material is at or above *B* a further rise in molecular weight would not be of great help and it will be preferable to spend time and money on other ways and means to improve the properties of the product.

Whereas Fig. 1 demonstrates a pronounced influence of DP on all phenomena connected with ultimate failure, it should be emphasized that other important properties such as specific gravity, rigidity, and melting point depend only very slightly if at all, on the molecular weight. Thus, 66 nylons of a wide range of DP's have essentially the same melting point; the melt viscosity *V*, of course, is greatly influenced by the molecular weight and increases proportionally to a power *n* of the DP

$$V = K(DP)^n$$

where *n* usually has values between 3 and 4.

Azial Order or Orientation:

The natural state of macromolecules in the dissolved or molten phase is that of an essentially randomly and irregularly coiled ball. If a mass of such molecules is immobilized either by the coagulation of a solution or by the freezing of a melt there results, in general, an amorphous or vitreous mass in which there is no preferred spatial arrangement of the molecular backbones or even of short segments of them. If we choose one of the segments of one macromolecule as reference unit and explore the surroundings, we shall find that in its immediate neighborhood there will be a certain short-range

order because of packing conditions, but a little bit further away—say 10 to 15 Å—there will be complete randomness in the position and orientation of the segments. Such an irregular and unorganized aggregate of polymer molecules will, evidently, lead only to a moderate lateral attachment of the segments and, as a consequence, to a structure that is not very resistant to mechanical deformation. In fact, vitreous or glassy polymers do not exhibit outstanding mechanical properties. It is, however, possible to parallelize, at least to a certain degree, the individual macromolecules in a sample and to arrive at an orientation of their axes parallel to one of the characteristic dimensions of the object under consideration. This can be done by "stretch spinning" a fiber, by drawing a spun fiber, or by stretching a film in one or two directions. In all these cases there results a substantial increase of mechanical strength parallel to the direction of the alignment of the molecular chains. The details of this reinforcement through orientation are different in each individual case, but the principal features are always similar and are represented in Fig. 2. It can be seen that in the domain of low degrees of axial orientation the strength is not very much affected by the alignment of the chains, but as the latter become increasingly parallelized there results a more and more effective lateral attachment of them to each other and the tensile strength increases very rapidly.

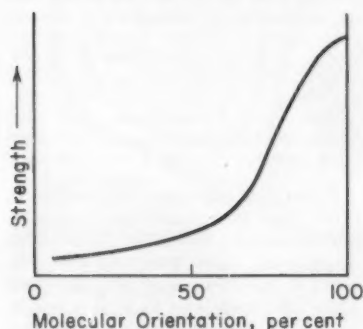


Fig. 2—Influence of molecular orientation on mechanical properties.

It can be expected that the beneficial influence of orientation will depend on the ease with which the chain molecules can be parallelized through mechanical action such as stretching, rolling, or extruding which, in turn, will be influenced by the intrinsic flexibility of the chains. The degree to which a given orientation will contribute to the development of mechanical strength should, on the other hand, depend on the presence of groups that can produce lateral attachment and on the magnitude of their intermolecular attraction.

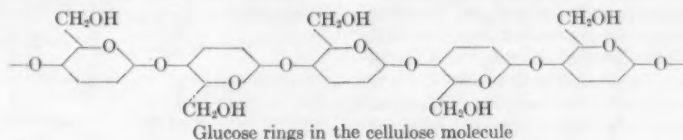
Thus we have two more factors to consider:

1. The flexibility of the chain molecules, and
2. The intermolecular attraction between them.

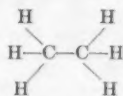
Both will affect the orientability of the polymer chains and the effects that a given degree of orientation have on the mechanical properties.

The Flexibility of Macromolecules:

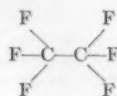
One of the pillars of organic chemistry is the principle of free rotation about a single C—C, C—N, or C—O bond and the rigidity of multiple bonds and of cyclic systems. Since its formulation about a hundred years ago, it has been



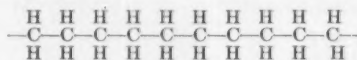
established that the degree of freedom depends on temperature and on the substituents that are carried by the C, N, or O atom. Thus, in ethane



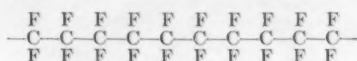
the two methyl (CH₃—) groups rotate virtually freely about the C—C bond at temperatures of 300 C but are somewhat restricted at room temperature and practically "frozen in" at -100 C. In hexafluoroethane



the rotation of the fluoromethyl groups (CF₃—) about the C—C bond is virtually absent at room temperature and can be completely activated only at rather high temperatures. Other substituents such as Cl, CH₃, C₆H₅, etc. have a similar restricting effect on the "free" rotation, which they convert by their presence in a "hindered" rotation. Now it can readily be seen that a long chain of many C—C bonds which carry hydrogen as a substituent, such as



will be, at a given temperature much more mobile than the corresponding chain which carries fluorine atoms as substituents:



The consequence of this fact on the thermal behavior of these two materials is very pronounced: The upper material—polyethylene—can be very easily oriented even at low temperatures but begins to soften around 100 C and melts to a rather fluid state at about 125 C, whereas the other—polytetrafluoroethylene—is much more difficult to orient but, because of the greater rigidity of its chains softens only at much higher temperatures and must be heated to about 330 C before it melts to a liquid of very high viscosity.

Another way to reduce the flexibility of a chain is the introduction of cyclic links which always carry with them the element of rigidity. Thus the molecules of cellulose which consist of glucose rings

are rather inflexible, which is responsible for the fact that cellulose has a very high melting point. These examples may suffice here to illustrate the fact that high melting can be produced by increasing the rigidity of the chain molecules of a polymer.

Intermolecular Attraction Between the Chains:

It is easy to understand that the melting point of a polymeric system will also be raised by the existence of strong intermolecular attraction between the chains, and the question therefore arises: How can this attraction be influenced? Many years of experience involving the melting and boiling behavior of low-molecular-weight organic substances have shown that there exist specific groups that develop strong intermolecular forces. For instance, two OH groups attract each other much more strongly than two CH₃ groups, which explains the fact that, at room temperature, water is a liquid whereas ethanol is a gas. The systematic study of the interaction of various groups with each other has led to the concept of molar cohesion and has resulted in the possibility of listing different groups in respect to their contribution to the molar cohesion. Table II gives such a list and expresses the magnitude of the group attraction by the energy, in calories, which is necessary to break the bond between the groups. It can be seen that the interaction between such nonpolar groups as CH₃, CH₂, C₆H₅— is relatively weak, whereas polar groups such as C=O or C—O—C cause a stronger attraction, and hydrogen bond-forming groups such as OH, COOH, or CONH

give the highest values for the molar cohesion. In fact, long flexible chains of hydrocarbon elements represent relatively low-melting or low-softening systems such as polyethylene, polystyrene, or polypropylene, whereas similar chains which carry OH- or CONH- groups are very high-melting even though they are as flexible as the others. Since the establishment of polar bonds or hydrogen bonds depends to a large extent on the exact geometrical fitting of the groups which bond with each other, it is understandable that a high degree of parallelization of the chain axes favors a close packing of the attractive groups and increases the efficiency of intermolecular bonding. We also will have to expect that not only the existence of attractive groups along the length of the polymer chains but also regularity of their distribution will be of importance for the effective establishment of intermolecular bonding. If groups with a high attractive potential are randomly distributed along the length of a macromolecule, the result of their attraction will be less than if their distribution is regular. In fact, many observations confirm the importance of stereoregularity on the melting characteristics and the mechanical behavior of polymeric systems.

The Use of Inorganic Elements:

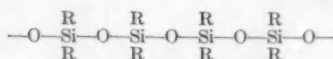
In summarizing the factors that contribute to rigidity, strength, and high melting characteristics, we arrive at the following:

1. High molecular weight,
2. Orientation of the chains,
3. Rigidity of the chains,
4. Presence of attractive groups, and
5. Regular distribution of these groups.

In fact during recent years, the systematic application of these principles has resulted in great progress in the improvement of the thermal and mechanical properties of many high polymers.

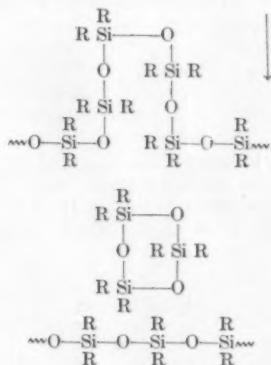
However, there still exists a gap in certain properties of the metals and ceramics on one hand and the synthetic "organic" polymers on the other, and it would be desirable to bridge this gap or at least to narrow it by the application of other principles and methods. One approach which has already been successful is the use of other elements than C, O, N, and H and the use of stronger bonds than the C-C, C-O, or C-N bond for the construction of the backbone of the long-chain molecules of a polymeric system. For several years it has been known that the Si-O bond has certain thermal advantages over the C-C bond, and considerable progress has been made in the synthesis and application of the silicone res-

ins which are of the general structure

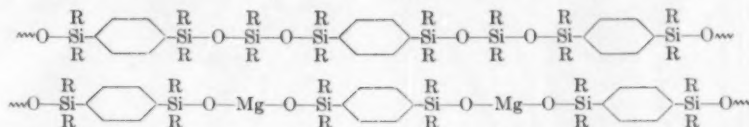


where R is an organic substituent such as CH₃, C₂H₅, C₆H₅, or CF₃. Some of these polymers have remarkably high heat resistance and also exhibit very interesting mechanical properties as coatings and rubbers. These successes have greatly stimulated further work in the field of inorgano-organic polymers, and a few of the more recently prepared types will now be reviewed.

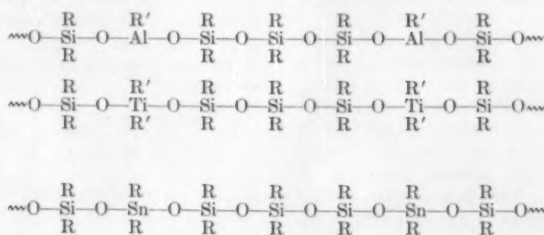
It was found that pure O-Si-O-Si-O chains have an undesirable tendency to fold back on themselves and to split out rings of relatively small size according to the scheme:



These rings act like plasticizers, and the progressive reequilibration of the long chains into a mixture of chains and



rings causes an undesirable softening of the system. In order to prevent or at least to delay this deterioration, there have been introduced into the backbone chain other inorganic elements such as aluminum, titanium, or tin to synthesize products of the following types:

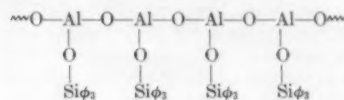


* Announced at a September, 1959 meeting of the American Chemical Society in Atlantic City, N. J.

where R can be CH₃, C₂H₅, C₆H₅, or CF₃ and R' can be OCH₃ or OC₆H₅.

Some of these combinations have been found to have superior heat stability and, at the same time, develop rather attractive mechanical properties.

It is also possible to build the backbone chain without any silicon and one could use the Si-O bonds to attach to the backbone certain groups that introduce desirable properties into the system. Andrianov³ has recently prepared a polymer of the formula



(φ = phenyl group)

which has a very strong and heat-resistant backbone chain of the aluminum oxide type, which in itself could be completely infusible and insoluble and, therefore, would lead to rather untractable materials. However, the attachment of the triphenyl silicon groups (-O-Siφ₃) renders this polymer soluble in hot hydrocarbons such as xylene or ethylbenzene and permits it to be spun, cast, or extruded from solutions of this type.

Another approach that seems to lead to promising materials is the stiffening of O-Me-O-Me chains (Me = metal) by organic-ring systems which are known to possess a high intrinsic heat stability. Materials of the following type have been prepared and are now under investigation;

These few examples may suffice to prove that there exist many ways to introduce such "inorganic" elements as magnesium, aluminum, silicon, titanium, zirconium, or tin into "organic" polymers and that, as a result, a very large number of new polymers can be prepared, some of which have already shown promising behavior in

the direction of narrowing the gap between metals and ceramics on the one hand and the classical organic polymers on the other.



No. 245 April 1960

Nineteen-Sixteen
Race Street
Philadelphia 3, Pa.

Final Arrangements Completed For Group Insurance Program

FINAL ARRANGEMENTS have now been completed for the new ASTM-approved Accident and Health Insurance program first announced in the April, 1959, ASTM BULLETIN. The insurance is available on a voluntary basis to official representatives of company and sustaining members, individual members, associate members, and their dependents.

For the past several years considerable thought and study have been given to this subject. Details of a specific insurance program for the members of our Society were thoroughly explored by the Finance Committee. Part of the investigation consisted of sending the proposed program to the Society's insurance counsellors and actuaries, Huggins & Co. The report from Huggins & Co. was eminently satisfactory, and the program was then approved by our Board of Directors. The brochure concerning the program and application forms were mailed to our members this month by the administrator.

The program contains three basic plans:

1. *The Loss-of-Time Plan.* Benefits for loss of time due to accident or sickness. Also benefits for accidental death or dismemberment. For ASTM members only.

2. *The Major Hospital-Nurse-Surgical Expense Plan.* Benefits for hospital room and board, miscellaneous hospital expenses, nurse expense while in a hospital and after hospital confinement, and surgery. This plan is offered with the option of either no-deductible or \$500-deductible coverage. It is available to members and their spouses and children.

3. *The Senior Hospital-Nurse-Surgical Plan.* More limited benefits for hospital room and board, miscellaneous hospital expenses, nurse expense while in a hospital, and surgery. This plan is designed primarily for members of the Society over 70 years of age and their spouses.

The key personnel of the administrator of the program have been successfully administering a similar program for the American Society of Civil Engineers for the past ten years, and a program for The American Society of Mechanical Engineers since June, 1958. They also administer a program for the American Society for Quality Control which was started March 1, 1959, and a program for the American Welding Society which was started December 1, 1959.

The program will be underwritten by the Continental Casualty Co. of Chicago, Ill.

There will be a charter enrollment period of six months from the date of the first mailing. During that time, if 50

"For Want of a Nail the Shoe Was Lost" For Want of a Standard the Order Was Lost!

AN EDITORIAL in the December, 1959, issue of *Concrete*, under the heading "A Bad Brick Calls—Long Distance," read, in part, as follows:

Would you expect that a bad Southwestern concrete brick would kill a big order for brick in the Midwest? Despite the miles between these two areas this can happen and, in fact, did happen not long ago.

We were told by a brick supplier that he just about had wrapped up a large order of brick to supply a multi-house development. It was wrapped up, that is, till the job superintendent killed the order and switched to clay brick. He did this because of a sad and bitter experience he's had with a poor quality concrete brick on an earlier job in the Southwest. Because of this, several million concrete brick weren't sold on this Midwest job...

The point is that you just don't know when a low grade product can cost somebody else a good sale, or how far the effect of a poor product can reach. You can't tell when you'll be hurt, or when you'll hurt someone else...

No one could guess how many sales are lost because of poor quality, or trace back all the reasons why sales aren't made. But we're sure that you can't get so isolated as to be immune to this problem.

This should prove to each plant that quality of our industry's products is something that affects each of us, not just a fine-sounding phrase piously uttered at sales meetings. Because of this, it's not just altruism but dollars and sense that make us urge higher quality standards for all concrete products and producers.

The editorial is pertinent and to the point. However, the editor might have gone a step further to illustrate how an ASTM standard would have prevented the loss of the sale by establishing a baseline for quality. This is an excellent case in point; the use of the proper ASTM specification for brick by the manufacturer and by the purchaser would have insured acceptance and recognition of the product without question, in any part of the country.

L. C. GILBERT

Executive Secretary R. J. Painter Leaves Hospital; Mending at Home

MEMBERS AND FRIENDS will be glad to know that after a hospital stay of several months, Mr. Painter has returned to his home, where he is convalescing and carrying out physical therapy for the purpose of strengthening his legs. The doctors feel that this change in environment should be quite helpful.

Mr. Painter's address is 1225 Cedar Road, Ambler, Pa.

**Last Chance to Enter
Photographic Exhibit**
See page 8

Changes of Address Take a Little Time

WHEN ADDRESS changes for our members are received at Headquarters, a little time must elapse (perhaps as much as several weeks) before the change can take effect and mail begins to arrive at the new address. One reason, of course, is that the change must be processed through Headquarters records, and the other is that addressed envelopes or labels with the old address are already in the hands of the printer for use when a printing job is completed. The best way to minimize any inconvenience is to send your new address to Headquarters as soon as you know what it will be.

per cent of the members enrolled in any ASTM District (or of the entire membership) apply for coverage, all applications received will be accepted regardless of the physical condition of the member (though members over 60 and impaired risks may be limited as to the amount of coverage they can purchase). If, however, less than 50 per cent of a local District applies, the insurance company will have the privilege of selection on the basis of health (unless 50 per cent of the entire ASTM membership has applied). (Any District with fewer than 100 members will be combined with another District for qualification purposes only.)

In the meantime, the insurance company has agreed to make the coverage effective for the insurable members after the first 100 acceptable applications from all Districts of the Society have been received, so that there will be no undue delay in coverage for those members who are in good health.

The following are some of the outstanding advantages of this group insurance program:

1. The insurance of an individual member cannot be cancelled by the company so long as he remains a member of the Society and the program remains in force. The Loss-of-Time Plan, of course, must be dropped when a member retires, but the Loss-of-Time Plan and the Major Hospital-Nurse-Surgical Plan can be carried up to the premium due date after a member reaches age 70. The Senior Plan will then be available.

2. The program is offered to members at rates substantially lower than the cost of similar coverage under individual policies.

3. There is no physical examination, and the application is an extremely simple one to fill out.

4. Once a certificate of insurance is validly in force, benefits cannot be reduced because of other insurance carried or because an insured performs duties of a more hazardous occupation.

5. The insurance program provides world-wide coverage and the broadest aviation clause available.

6. If sickness disability begins after the effective date of a certificate of insurance, coverage is provided, regardless of the date of origin of the ailment. Once a certificate is validly in force, it cannot be changed to eliminate coverage of this ailment.

7. The Major Hospital-Nurse-Surgical Plan is available with a \$500-deductible option, so as to eliminate duplication of benefits with a basic hospital expense plan a member may already carry. However, unless other coverage is of a catastrophic nature, this plan may be superimposed on a basic plan, even though there may be some duplication of coverage.

8. Benefits from the Society's insurance program will be paid regardless of any other insurance the member may carry.

The success of the program will depend upon the interest and active support of our membership. The Board of Directors feels that this is a worthwhile project, and it is urged that each member give the matter serious consideration.

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
April 26	Detroit District	Detroit, Mich.
April 26-27	Committee C-19 on Structural Sandwich Constructions	Madison, Wis. (Forest Products Laboratory)
April 27	Central New York District	Syracuse, N. Y.
April 27	Committee C-14 on Glass and Glass Products	Philadelphia, Pa. (Warwick Hotel)
April 28	Committee D-22 on Methods of Atmospheric Sampling and Analysis	Rochester, N. Y.
May 5	Committee E-11 on Quality Control	Philadelphia, Pa. (Society Headquarters)
May 6	New England District	Worcester, Mass.
May 26	Committee D-25 on Casein and Similar Protein Materials	Chicago, Ill. (Edgewater Beach Hotel)
June 16-17	Committee F-1 on Materials for Electron Tubes and Semiconductor Devices	Boston, Mass. (Statler Hotel)
June 26-July 1	Annual Meeting	Atlantic City, N. J. (Chalfonte-Haddon Hall)
May 19	Committee D-21 on Wax Polishes and Related Material	Chicago, Ill. (Drake Hotel)
Sept. 13-15	Committee B-5 on Copper and Copper Alloys, Cast and Wrought	Niagara Falls, Ont. (Sheraton-Brock Hotel)
Sept. 27-29	Joint ASTM-TAPPI Committee on Petroleum Wax	Grand Rapids, Mich.
Oct. 17-18	Committee B-9 on Metal Powders and Metal Powder Products	Philadelphia, Pa. (ASTM Headquarters)
Oct. 18-21	Committee D-13 on Textile Materials	New York, N. Y. (Sheraton-McAlpin Hotel)

International Arc Tracking Test

THE INTERNATIONAL Electrotechnical Commission has published the first edition of IEC Publication No. 112, "Recommended Method for Determining the Comparative Tracking Index of Solid Insulating Materials under Moist Conditions."

The test method described in the new publication is intended to indicate the relative susceptibility to surface tracking of solid insulating materials when exposed, under electric stress, to water and other contaminants from the surroundings.

ASTM Committee D-9 on Electrical Insulating Materials has been working on a similar test for dust and fog tracking. A suggested method was published as information in the 1957 Compilation of ASTM Standards on Electrical Insulating Materials and is available as a separate reprint. A reproducible test for arc-tracking resistance under adverse surface conditions is very much needed, and it is expected that the IEC document will be a worth-while contribution toward reliable evaluation of this elusive property of insulation. ASTM interests are represented on the IEC committee.

The International Electrotechnical Commission is the coordinating body for international standards in the field of electricity and electronics. American interests in IEC work are represented by the U. S. National Committee for the IEC, an arm of the American Standards Assn. The IEC tracking method is available at \$2.40 a copy from the ASA, Dept. PR 116, 10 E. 40th Street, New York 16, N. Y.

Roy E. Olson Named First ASTM Fellow

Five Grants-in-Aid also Allocated

ROY E. OLSON has been selected by the University of Illinois Graduate College as the first ASTM Fellow. The University of Illinois was given the first ASTM free-grant doctoral fellowship to be administered under its own rules and regulations governing fellowships. It provides for an award of \$6500—\$1500 for the University and \$5000 for a student entering the final year of full-time graduate work on his doctor's degree relating to the knowledge of materials.

The fellowship and grants-in-aid program was established recently by the Society's Board of Directors to further the work of ASTM in the field of research and standardization for materials. The program is to continue for five years, with awards being made to different schools each year.

Mr. Olson's research, which began almost three years ago, is concerned with the basic engineering phenomena of clays. It is directed toward the understanding of the basic physicochemical mechanisms that control the engineering properties of cohesive soils. These properties are affected by so many variables and in such a complicated fashion that a complete solution to the problem is not now possible. The investigation is with the finer than 2- μ (particle diameter) fraction of the clay mineral illite, obtained from a Pennsylvanian shale near Fithian, Ill.

Research on the ASTM Fellowship will include a study of the consolidation characteristics of 2- μ magnesium illite that has been slowly sedimented from suspension in solutions of magnesium chloride ranging in concentration from 10 N down to 1×10^{-5} N. Studies of the effective stress-shear properties of calcium 2- μ illite are being continued. Triaxial equipment is being used.

Mr. Olson is a native of Richmond, Ind. He attended high school at Minneapolis, Minn., received his B.S. in engineering in June, 1953, from the University of Minnesota, and his M.S. in civil engineering in 1955 from the same University. Mr. Olson's summer employment has all been related to soils engineering and research. The summer of 1954 was spent at Thule, Greenland, with the Snow Ice and Permafrost Research Establishment, U. S. Army Corps of Engineers. The summers of 1955 and 1956 were spent with the firm of Dames & Moore, Los Angeles and San Francisco; and the summer of 1957 with Woodward-Clyde and Associates, Denver, Colo. During the academic



ROY E. OLSON
FIRST ASTM FELLOW

year of 1955 and 1956, Mr. Olson was teaching assistant in the civil engineering department, University of Minnesota, and since then has been at the University of Illinois as research assistant and instructor. He received the Minnesota Surveyors and Engineers Society scholarship for the academic year of 1954-1955. He is a member of Chi Epsilon, the American Society of Civil Engineers, and an Associate Member of ASTM.

Grants-in-Aid

In addition to the Fellowship, the Society also recently made five \$1000 Grants-in-Aid, one each to California Institute of Technology, Cornell University, The University of Minnesota, Northwestern University, and The Rice Institute.

The California Institute of Technology has applied its grant-in-aid to the purchase of a cathode ray oscilloscope which will be used immediately to further the research work being done by Mr. Kenneth R. King and others concerned with research in materials. The oscilloscope is a key factor in his research, which previously could be done only with considerable inconvenience and loss of time by borrowing similar equipment. Having the oscilloscope available will greatly expedite Mr. King's program of study.

Mr. King holds a Shell Fellowship and is engaged in the study of the influence of rapid loading and temperature upon the critical resolved shear stress for the initiation of slip in the basal plane of zinc single crystals. There has been some argument as to whether or not a

distinct yield point exists for zinc single crystals and, hence, whether or not there is a time delay for the initiation of yielding as there is in mild steel. This investigation will assist in securing a better understanding of the mechanism of the initiation of plastic deformation and fracture in metals. Work in this field has been conducted at Cal Tech by Profs. Donald S. Clark and David S. Wood for several years. Mr. King's research is an extension of the work initiated by Clark and Wood.



KENNETH R. KING
FIRST ASTM GRANT-IN-AID RECIPIENT

Mr. King received his B.S. degree in engineering from the California Institute of Technology in 1953. He received the degree of Master of Science in Mechanical Engineering in 1954, also from Cal Tech. He assisted in investigations on the dynamic properties of materials and was coauthor of a report entitled "A Further Investigation of Dynamic Stress-Strain Relations for Annealed 2S Aluminum Under Compression Impact." He was also the author of a report, "Study of the Yield Phenomenon in Zinc Single Crystals." Mr. King was awarded a Fulbright Fellowship for study in Europe during the year 1958-1959, during which time he was in residence at the Technische Hochschule in Stuttgart, Germany, where he engaged in research on engineering materials and attended some lectures, studying under Professor Seeger. Mr. King returned to the California Institute of Technology in September, 1959, to resume his work for the doctor's degree.

The other four institutions receiving grants-in-aid have not yet made their selections of recipients. As soon as word is received, the stories will be published in the ASTM BULLETIN.

International Powder Metallurgy Conference

TWO DAYS OF technical sessions and two days of plant tours comprise the 1960 International Powder Metallurgy Conference to be held June 13-17. Site of the technical sessions will be the Biltmore Hotel, New York, N. Y. Sponsoring organizations are the Metal Powder Industries Federation and the Powder Metallurgy Committee, Institute of Metals Division, The Metallurgical Society, American Institute of Mining, Metallurgical, and Petroleum Engineers. The technical program includes the following symposia and paper titles:

Symposium on Powder Metallurgy Fundamentals and Theory

Theory of Solid-State Sintering
Sintering Mechanism of Titania
Sintering Behavior of Organic Materials
Interparticle Contacts in Sintered Powders
Mechanism of Liquid-Phase Sintering
A Plastic-Flow Model of Hot Pressing
Microhardness in Powder Metallurgy Research
Sintering of Fine Oxide Particles Produced by Calcination
High-Density Sintering of Metal Powder Compacts
Sintering with a Chemical Reaction, as Applied to Uranium Monocarbide

Symposium on Dispersion Strengthening The Role of Powder Metallurgy in Dispersion Strengthening Alloy Development

A Theory of Dispersion Strengthening
Dispersed Phase Hardening in Copper
Properties of Nickel Containing Dispersed ThO_2
Internal Oxidation of Dilute Ni-Cu Alloys for Dispersion Strengthening
Dispersion Strengthened Steels

Symposium on Powder Metallurgy Technology and Methods

Roll Forming of Metal Powders
Hot Extrusion of Metal Powders
Hydrostatic Pressing of Metal Powders
Slip Casting of Metal Powders and Metal-Ceramic Combinations
Explosive Forming of Metal Powders
Lubricants for Powder Metallurgy Parts Manufacturing and Their Influence on Properties
Large Sintered Bodies and Parts

Symposium on Powder Metallurgy Alloys, Materials, and Applications

Refractory Powder Metallurgy Alloys and Products
Recent Investigations of High-Temperature Alloys of Molybdenum and Tungsten
Heat-Resisting Materials by Powder Metallurgy
Influence of Processing and Design Variables on Properties of Sintered WC-Co Alloys
Effects of Spark Erosion on Some Cemented Carbides
Recent Trends in European Metal Powder Parts Manufacture
An Exploratory Investigation of Pre-

MATERIAL QUESTIONS

NEARLY EVERY day the mail at ASTM Headquarters includes some questions about materials, specifications, test methods, or related problems. We feel that the answers, many of which are based on information given us by officers of committees in their capacity as committee officers, are of general interest. For the most part, inquiries we receive are related to the activities of the Society, either standards, research work, or publications. Often, an inquiry is such that the services of a consultant or independent testing or research laboratory is obviously required; in this event we do not hesitate to so recommend.

Coal Burning Properties

The value of the coke button index [see *Standard Method of Test for Free-Swelling Index of Coal*, ASTM Designation: D 720-57] has been questioned by certain coal technologists. They have produced letters from various sources stating that this test is not significant of the burning characteristics of coal, especially as applied to combustion of pulverized coal.

It is my opinion that the coke button index, ASTM D 720-57, will show the relative oxidation of coals (bituminous) and will indicate by a simple test the relative rate of heat release to be expected; that is, if a coal normally shows a No. 9 index when freshly mined and upon exposure to the elements for a time then shows an index of, say, No. 4, it appears reasonable to expect that this latter coal will burn more slowly than the former, and this will reflect significantly in boiler room efficiency and in the economics of the boiler room as well.

● You do not appear to have a complete understanding of the effect of the free-swelling index on burning properties of various coals. As a result, your conclusions in this respect are not entirely correct, owing to the fact that you have reasoned from a particular instance to a generalized case.

In order to clarify this point, your first example of a No. 9 index coal, which on exposure develops a No. 4 index, should be considered in detail. Coals having a No. 9 index are highly caking coals and would not normally be burned in competition with coals having a No. 4 index, which are weakly caking or free-burning coals. Therefore, a plant which normally burned a No. 9 index coal satisfactorily might be expected to encounter boiler room difficulties if it suddenly switched to a No. 4

alloyed Powders of Aluminum
Titanium and Zirconium Powder Metallurgy
Behavior of Lubricant in Porous Bearings
Sintered Metallic Friction Material Applications
Shrinkage Compensation Through Alloying
Recent Advances in the Powder Metallurgy of Beryllium

index coal without forewarning; but the boiler room difficulties would probably stem more from a difference in heat content than from a difference in the caking properties of the two coals.

On the other hand, a plant which normally burns a No. 4 index coal satisfactorily would no doubt have as much or more difficulty burning a No. 9 index coal; and the trouble would stem from a difference in the caking properties, rather than a difference in heat content. In other words, boiler room difficulties should be studied, not just from the standpoint of the coal analysis, but by matching the characteristics of the coal with the combustion characteristics of the burning equipment. If a coal is misapplied, obviously it will not perform satisfactorily.

The Pennsylvania Railroad has made a very comprehensive study of the relation of the free-swelling index to the burning of various coals on railroad locomotives at their Test Department in Altoona, Pa. They may be able to furnish you with data on this phase of the subject.

Yellowness Index for Plastics

In evaluating plastics for suitability for use in lighting applications, I have been using ASTM methods for luminous reflectance, transmittance, and color of materials (D 791-54). I have been informed that there is a so-called yellow index used as a measure of discoloration of plastics on exposure to light and would appreciate information about this term.

● Yellowness index is defined by:

$$\text{yellowness index} = \frac{100(T_{420} - T'_{420}) - (T_{680} - T'_{680})}{T_{560}}$$

where:

T_{420} = original transmittance at 420 μ ,
 T'_{420} = final transmittance at 420 μ ,
 T_{680} = original transmittance at 680 μ ,
 T'_{680} = final transmittance at 680 μ ,
 T_{560} = original transmittance at 560 μ

This equation was originated by the Dow Chemical Co. and recommended by the SPI-IES-NEMA Joint Committee on Plastics for measuring the discoloration of plastics in fluorescent lighting applications. This test method is outlined in the 1959 IES Handbook and refers to ASTM Method D 791 for obtaining the transmittance values before and after exposure to fluorescent lights. The equation is used exclusively in the plastic and lighting industries for judging the performance of competitive resins under accelerated and normal aging.

A modern turbojet engine consumes about 1 lb of fuel per hour for every pound of thrust. An advanced bomber, such as the B-58 "Hustler" with four turbo-jet engines, would burn up about 48,000 lb of fuel per hour.

**Last Chance to Enter
Photographic Exhibit
See page 8**

NEW ASTM PUBLICATIONS

Stress-Corrosion Cracking of Austenitic Chromium-Nickel Stainless Steel

WHEN CERTAIN compositions of stainless steel are exposed to particular corrosive environments, and simultaneously are under stress due to previous cold working or service loads, spontaneous cracking may occur. The problems associated with stress-corrosion cracking are influenced by numerous conditions. This report, sponsored jointly by ASTM Committee A-10 on Iron - Chromium, Iron - Chromium - Nickel, and Related Alloys, and Committee T-5E of the National Association of Corrosion Engineers, includes information gathered through an extensive international survey covering 145 case histories from the United States and England.

The volume reviews the case histories and the present status of research work in this field. Extensive tabulated data of the case histories, and a well-annotated bibliography covering references up to June, 1959, are also included.

Reviewed are such elements of the problem as identification of stress-corrosion, susceptible compositions, influence of heat treatment, surface finish, critical environments, corrosion, and preventive measures. Included in the contents:

Part I. Review of Case Histories

Introductory Summary—F. L. LaQue
General Information—A. W. Dana, Jr., and W. Z. Friend

Equipment, Mode, Location of Fractures, and Associated Conditions—E. E. Denhard

Classification of Materials and Stress Conditions—F. K. Bloom

Classification of Corrosion Conditions—W. B. Brooks and M. E. Holmberg
Steps Taken to Overcome Cracking—F. K. Bloom

Part II. Present Status of Research Effort
Survey of Current Research Activities—A. W. Dana, Jr., and W. Z. Friend
The Mechanism of Stress-Corrosion Cracking of Austenitic Stainless Steels—Julius J. Harwood

Appendices

Case History Data from U.S.A.
Case History Data from United Kingdom
Annotated Bibliography, 1935 to June 1959.

STP 264, 96 pages, heavy paper cover, 8½ by 11 in., price \$6, to ASTM and NACE members \$4.80.

Rubber Products

Compilation of Standards, D-11

THIS 19TH EDITION of the D-11 compilation is over 10 per cent larger than the preceding edition, published in May, 1958. Its 163 standards include 22 that are completely new and 66 that have been revised or changed in status. Among the new standards are several covering cellular materials of poly(vinyl) chloride or copolymers and urethane foam, two on the effects of radiation, one on abrasion resistance of rubber soles and heels, one on testing automotive air conditioning hose, and several prepared by Committee D-24 on Carbon Black.

Selected topics include the following:
Chemical Tests of Vulcanized Rubber
Physical Tests of Vulcanized Rubber
Electrical Tests
Aging and Weathering Tests of Rubber
Low-Temperature Tests of Rubber
Automotive and Aeronautical Rubber
Packing and Gasket Materials
Hose and Belting
Tape
Electrical Protective Equipment
Insulated Wire and Cable
Hard Rubber
Latex Foam, Sponge, and Expanded Cellular Rubber
Synthetic Elastomers
Compounding Materials
Nomenclature and Definitions

ASTM Standards on Rubber Products, 1052 pages, hard cover, price \$9.75, to members \$7.80.

Plastics

Compilation of Standards, D-20

THE INCREASE in size of this eleventh edition of the D-20 compilation of standards reflects the rapidly growing pace of the relatively new plastics industry. This edition contains a total of 213 standards, of which 22 are entirely new and 23 have been revised or changed in status. In addition to all of the standards prepared by Committee D-20 on Plastics, the compilation includes selected standards from other committees, notably Committee D-9 on Electrical Insulating Materials and Committee D-11 on Rubber and Rubber-Like Materials, which should be of interest to those in the plastics field.

Among the topics covered are (number of new standards in parentheses):

Specifications for Molding Compounds and Base Materials (2)

Standard and Molded Shapes (2)
Mechanical Properties of Plastics (5)
Effects of Radiation (2)
Thermal Properties of Plastics (3)
Optical Properties of Plastics (2)
Permanence Properties of Plastics (2)
Analytical Methods for Plastics (3)
Molds and Molding Processes for Plastics
Definitions and Nomenclature of Plastics
Conditioning of Plastics
Electrical Insulating Materials (1)
Rubber and Rubber-Like Materials
Adhesives
Color and Gloss Tests
Miscellaneous Subjects (2)

ASTM Standards on Plastics, 1244 pages, hard cover, price \$9.00, to members \$7.20.

Radioisotopes in Metals Analysis and Testing

THE USE of radioisotopes in the analysis and testing of metals is not meeting with the widespread acceptance predicted in the years immediately following World War II. This symposium, aside from presenting several specific applications in analysis, has as its purpose the review of instruments and techniques available to the analyst with the purpose of stimulating thinking in the application of radioisotopes in this area. The contents include:

Introduction—W. W. Meinke
Nucleonics in Analysis—W. W. Meinke
Instrumentation for Nucleonics—A. H. Emmons
Metals Analysis by Radioactivation—G. H. Morrison
Principles of Isotope Dilution Assays—C. Rosenblum
Neutron Activation Analysis of Traces of Molybdenum in Tungsten—J. F. Cosgrove
Application of the (n, α) Reaction—A. H. Bushey and B. Thompson
Experience with Neutron Activation in the Analysis of Aluminum—J. E. Lewis
Training Industrial Personnel in Radioisotope Utilization—J. P. Danforth

STP 261, 68 pages, hard cover, price \$2.75, to members \$2.20.

Corona Method Available

SOCIETY MEMBERS who have purchased a copy of the 1959 edition of ASTM Standards on Electrical Insulating Materials (D-9) may write Headquarters for a copy of the Suggested Method for Corona Measurement which appeared in the 1957 edition of the book as Appendix IV. Other requests will also be honored, but there will be a small charge. The suggested method was inadvertently omitted from the 1959 edition.

Rubber Conference Papers

THE PROCEEDINGS of the International Rubber Conference, held in Washington, D. C., November, 1959, contains 72 papers presented at the 12 sessions of the conference sponsored by the Division of Rubber Chemistry, American Chemical Society; ASTM Committee D-11 on Rubber and Rubber-Like Materials; and Rubber and Plastics Division, The American Society of Mechanical Engineers.

The papers cover such topics as tires, aging, sealants, natural rubber and latex, elastomers, elastomer reinforcement, synthetic rubber latex, polymers, vulcanization, theory, and advances in test methods. The book consists of preprints of the presented papers edited by the staff of the Applied Publications of the American Chemical Society.

Proceedings, International Rubber Conference, 616 pages, heavy paper cover, price \$12.50, to members of sponsoring organizations \$10.

Marine Atmosphere Exposure of Galvanic Couples Involving Magnesium

THE NEED for information for the selection of metals, dissimilar metal couples, and protective systems in military communication and associated equipment is recognized because of the high incidence of corrosion failure of such equipment. This is particularly true of conditions encountered in coastal and beachhead areas.

Marine environments apparently are among the most severe conditions encountered. Experience has shown that certain coastal areas of California represent an ideal testing area for signal equipment protection because of frequent heavy fog conditions coming in from the sea. It has been suggested that galvanic couples that can withstand the corrosive environment of this area would provide satisfactory service under most natural environments elsewhere.

This publication reports the results of exposure tests of protective systems for magnesium, including chromate conversion, anodic coatings, and paint systems of chromate primer and alkyd, phenolic, and epoxy enamels. Suitable controls were included in the experiment, and inorganic and organic protection for the cathode metals also were studied.

The data presented permit the selection, for each couple, of protective systems serviceable under severe marine atmospheric conditions. Experimental work and tabulation of data were done by A. Gallachio and J. Cornet.

STP 255, 32 pages, heavy paper cover, price \$2.25, to members \$1.80.

Symposium on Hydraulic Fluids

CENTRAL HYDRAULIC systems for automobiles have become a reality with the development of reliable hydraulic fluids and systems. Now, with man's projected entry into outer space, hydraulic fluids are being called on for use in a variety of control systems never before envisioned. These are only two of several timely topics covered in this Symposium on Hydraulic Fluids.

In addition to applications in automobiles and missiles, hydraulics for marine, aircraft, and industrial use are discussed. Fire resistance, a characteristic of great importance in most applications of hydraulic fluids, is covered at length.

The reader will find significant advances in hydraulic fluid technology revealed in this symposium. Included in the contents are:

Objectives and Activities of Technical Committee on Hydraulic Fluids—W. H. Millett

Are Hydraulics Holding Their Own?—R. Q. Sharpe and K. G. Henrikson
Automotive Central Hydraulic Systems and Their Fluid Requirements—T. H. Risk

Is Hydraulics Out of This World?—G. R. Keller

Spray Flammability Test for Hydraulic Fluids—H. H. Rowand

Hydraulic Fluids for Use in High-Pressure Shipboard Equipment—H. F. King and J. A. Coil

New Developments in High Performance Fluids for Military Aircraft and Industrial Applications—T. G. Smith

Emulsion-Type Fire-Resistant Industrial Hydraulic Fluids—C. E. Francis and H. E. Sipple

Development and Testing of Aircraft Hydraulic Fluids—R. L. Peeler and S. A. Kovacich

STP 267, 108 pages, hard cover, price \$3.75, to members \$3.00.

Index to ASTM Standards Available

THE 1959 INDEX to ASTM Standards, which serves as a guide to all ASTM specifications, methods of testing, recommended practices, definitions of terms, charts, and tables is now available. The Index is an adjunct of the Book of ASTM Standards and comprises a ready reference to the Book in any of its ten Parts and also the Methods of Chemical Analysis of Metals. The Index can be used to ascertain whether or not the Society has issued a standard on a specific subject. Both subject and numerical indexes are included.

216 pages, single copy free on request, extra copies \$1.00 each.

Metallic Electrical Conductors

Compilation of Standards, B-1

THE GROWTH of the electrical power industry over the last two decades has been phenomenal. It promises to continue at an accelerated rate. In the wake of larger and more efficient electric producing installations, a growing network of distribution systems has been superimposed on an already impressive power distribution grid. The need for more efficient electrical conductors and better cable design has required that we extend our knowledge of the materials used for electrical conductors. This volume contains all of the standards published by ASTM in this field. It supersedes the 1957 edition.

Contained in the book are 59 standards, of which three are completely new and 36 are revised or changed in status. The new standards are for bare aluminum wire for electrical conductors, for aluminum-coated steel core wire, and for testing electrical conductivity by use of eddy currents.

Of particular interest to the utilities and to wire and cable manufacturers, this book also contains standards of interest to the electronic and communications industry. Among the materials covered are copper, copper alloys, copper-covered steel, aluminum, aluminum-covered steel, and galvanized steel and iron.

ASTM Standards on Metallic Electrical Conductors, 366 pages, hard cover, price \$4.50, to members \$3.60.

Revised Test for Fuels over 100 Octane Published

PETROLEUM TECHNOLOGISTS now have a research method for determining the knock characteristics of motor fuels above 100 octane. The new tentative method is included in this 1960 edition of the Manual for Rating Motor Fuels by Motor and Research Methods. In addition, the other standards in the volume for rating motor fuels below 100 octane have been revised and brought up to date.

The volume contains six extensive appendices which present in a systematic way by word and picture, factual information and data on the operation and maintenance of the knock-testing equipment. These appendices discuss apparatus, reference materials, operation, maintenance, installation, and building and utility requirements. Two methods are described in the addenda to this book.

Manual for Rating Motor Fuels by Motor and Research Methods, 1960 Edition, 224 pages, cloth cover, price \$7.50, to members \$6.

Creep Behavior Data Amassed

TO DETERMINE the state of knowledge in the field of stress concentrations under cyclic loading, the ASTM-ASME Joint Committee on Effect of Temperature sponsored a two-part project to survey the published literature relating to cyclic loading and the influence of stress concentrations at elevated temperatures. The result is this publication which brings into focus in a comprehensive fashion the vast amount of information available on these subjects.

The survey covering the effects of nonsteady load and temperature conditions on creep of metals describes the fundamental investigations, summarizes data on alloys under complex variations of load and temperature, and reviews several analytical procedures for calculating nonsteady behavior from steady-state stress tests.

The survey on stress concentrations reviews the available notch-rupture data with the idea of establishing fundamental influences of stress concentrations, testing variables, and the influence of alloy compositions. Also included is a section dealing with the application of notch data to the problem of component design.

Extensive use has been made of graphs for presentation of data. Complete bibliographies are also included.

Literature Surveys on Influence of Stress Concentrations at Elevated Temperatures and the Effect of Nonsteady Load and Temperature Conditions on the Creep of Metals, 90 pages, heavy paper cover, 8½ by 11 in., price \$4.50, to ASTM and ASME members \$3.60.

Adhesion; Relation of Metal Structure and Properties On Program for 1960 Gordon Research Conferences

TWO PROGRAMS of the 1960 Gordon Research Conferences of special interest to ASTM members are those on Adhesion and on Physical Metallurgy—Relation of Structure and Properties. Topics and contributors for these programs are as follows:

Adhesion (Aug. 29 to Sept. 2, New Hampton School, New Hampton, N. H.)
The Science of Adhesive Joints—J. J. Bikerman
Degradation of Adhesive Joints Through Heat or Aging—F. J. Reil
Mechanism of Failure—G. R. Irwin
Absorption of Adhesives on Surfaces—F. R. Eirich
Adhesion and the Chemical Nature of Surfaces—W. T. M. Johnson
Investigations with Atomically Clean Surfaces—H. E. Farnsworth
Relation Between Resin Composition, Physical Properties, and Bond Strength—C. A. May and A. C. Nixon

Factors Which Affect Adhesion of Cellulose Fibers—John W. Swanson
Science of Adhesion Through Ceramic and Inorganic Compounds—D. V. Rosato

Physical Metallurgy—Relation of Structure and Properties (June 27 to July 1, Kimball Union Academy, Meriden, N. H.)

Effect of Impurities and Defects in Superconductors—R. D. Seraphim
Theory of Resistance Minimum in Dilute Paramagnetic Alloys—A. W. Overhauser
Low Temperature Thermoelectric Behavior in Pure Metals and Dilute Alloys—W. B. Pearson
Deformation of Solid Solutions—P. A. Flynn
Influence of Grain Size on Deformation—D. A. Thomas
Relationship Between Surface Orientation and Film Formation in Aqueous Solutions—J. Kruger
Mechanism of Dislocation Etch Pitting—F. W. Young
Electrodeposition and Defect Structure—D. A. Vermilyea
Shock Loading—J. E. Dorn
Dispersion and Creep—J. W. Nutting
Oxidation Characteristics of Zirconium, Titanium, and Hafnium—W. W. Smeltzer
Oxidation of Metals in Carbon Monoxide-Dioxide Mixtures—B. Wagner
Ductile Fracture—W. A. Backofen
Brittle Fracture—T. L. Johnston
Origin of Anisotropy in Thin Magnetic Films—D. O. Smith
Ferromagnetic Resonance Studies of Whiskers and Particles—D. S. Rodbell
Roll Magnetic Anisotropy—S. Chikazumi
Magnetic Annealing in Permalloys—E. A. Nesbitt
Ferromagnetism and Antiferromagnetism in Alloys—A. Arrott
Electronic Specific Heat and Resistivity of Chromium Alloys—P. Beck

The Gordon Research Conferences were established to stimulate research in universities, research foundations, and industrial laboratories. The informal types of meetings include scheduled lectures and discussion groups. Time is provided for informal discussions among the members of each conference. Meetings are held in the morning and in the evening, Monday through Friday, except for Friday evening. Afternoons are free for recreation, reading, or participation in discussion groups as the individual desires. The purpose of each program is to bring experts up to date on the latest developments, to analyze the significance of these developments, to provoke suggestions concerning the underlying theories and profitable methods of approach for making progress. It is not to review the known fields of chemistry and physics.

Requests for further information should be addressed to W. George Parks, Director, Department of Chemistry, University of Rhode Island, Kingston, R. I. From June 13 to Sept. 2, mail should be addressed to Colby Junior College, New London, N. H.

Quality Control for the Small Manufacturer

GUIDANCE IN SETTING UP a quality control and technical development laboratory is offered the small manufacturer in a four-page Technical Aid published recently by the Small Business Administration. More and more small manufacturers are finding that quality control and technical development are essential for success. Many are surprised to learn that they are not very complicated or costly to get started.

The Technical Aid discusses such topics as tax advantages, equipment required, use of independent laboratories, preparing personnel for the change, locating qualified technicians, and writing the quality control report. Copies are available free from field offices or Washington headquarters of the Small Business Administration.

Committee D-12 Award To Anthony M. Schwartz

ANTHONY M. SCHWARTZ has received the 1960 award for outstanding achievement in the field of soap and detergent technology, made annually by Committee D-12 on Soaps and Other Detergents. The presentation was made March 15 during the committee's annual meeting at the Park Sheraton Hotel in New York City.

The citation recognizes Dr. Schwartz' accomplishments in the field of detergents and his contributions to the committee's work in standardizing test methods and specifications for detergents. Dr. Schwartz has been a member of Committee D-12 since 1952, and before that was a consulting member of the committee. He is presently chairman of the group on nomenclature and definitions.

Dr. Schwartz is manager of the Industrial Chemical Division of Harris Research Laboratories, Washington, D. C. He is a member of the American Chemical Society, American Association of Textile Chemists and Colorists, American Oil Chemists Society, American Association for the Advancement of Science, Society of Cosmetic Chemists, American Institute of Chemists (Fellow), and the Washington Academy of Sciences.

**Last Chance to Enter
Photographic Exhibit
See page 8**

The Meaning of Measurement

W. O. BAKER¹

EVERYONE REGARDS measurement as the essence of testing, and usually the abundance and precision of measurement imply the validity of a test. The language of measurement has become, in fact, a primary mode of expression of our technical age. For example, ironically, "horsepower" pervades our speech and thought increasingly as horses vanish from the earth. We have imagined that an advance in understanding of the universe through science has authenticated the power and absolutism of measurement. Actually, it has emphasized the difficulties of measurement and the qualifications which must be attached to it. This uneasy realization came strongly with the advent of general relativity theory; and in the works of Jeans, Milne, and many others, following Einstein's concepts, the extreme difficulty of measurement of mass, length, and time in cosmic actions was exposed. Similarly, in the past 30 or 40 years keen critiques of the momentum-time measurement problem were formulated by Heisenberg, deBroglie, Dirac, and others. They have shown that also within the atom, or, more broadly, in places where the action involved is comparable to a quantum of energy, we also make a measurement meaningful only by very precise specifications of the conditions under which it was made.

With characteristic insight, Prof. Niels Bohr, in a lecture delivered two years ago, reviewed the whole matter of physical observations, or, more broadly, the problem of describing physical experience. He summarized the present situation as follows: "If, in atomic physics, phenomena are observed under different experimental conditions and are described by different physical concepts, they cannot be combined into a simple picture. If the attempt is made, we get apparent contradictions."

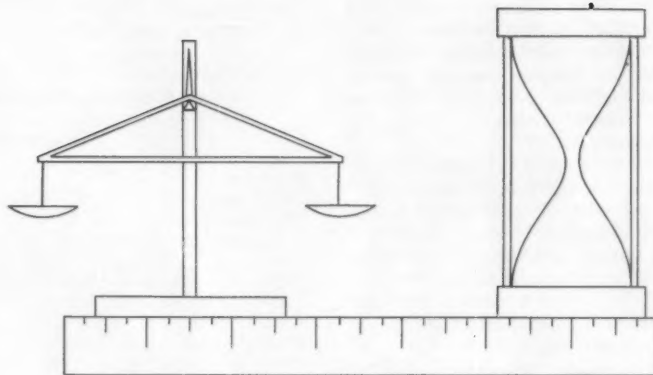
This issue is being increasingly developed in atomic and nuclear physics and, of course, is most clearly under-

stood in behavior described by quantum mechanics. On the other hand, in classical measurements the remarkable range of relaxation times which fundamental units of matter can show is causing equally grave concern about the meaning of many of our most common measurements of stress-strain, of dielectric, magnetic, optical, and acoustical properties. While even before Maxwell it was realized that relaxation times τ could be expected to be related to a general "internal" viscosity η and a rigidity G as: $\tau = \eta/G$, the growth of molecular theory in recent decades has revealed a range of τ 's extending, for instance, in macromolecular substances like plastics, rubbers, textiles, and other polymers over a range of more than 10^{15} .

Another way of expressing this difficulty of obtaining a measurement of a property of matter which is truly independent of the method of measurement, the time of test, or the like, is to consider the information content of a test signal. The thing being measured might, for instance, be the extension of a specimen of polymer under a given load. A signal representing the change in length caused by this load may be a very narrow-band signal from some fast recording method, depending on strain gages or other electrical transducers being employed. If it is, and if it comes, for instance, from the balance

of a bridge circuit, as is often the case in modern instrumentation, the resulting measurement may require many trials before complete information from the signal is obtained. For instance, if a bandwidth of only 50 cps is used in order to tune sharply the response of a 60-cps test circuit to the original load, a minute or more may be required just to find a balance in the electrical measuring ingredients of the system and, accordingly, the mechanical behavior of the specimen may be considerably obscured.

Nevertheless, we see enlarging volumes of data generated by proliferated instrumentation, in which the machinery is becoming so elaborate that it is impractical in reporting results to describe exactly what the experimental conditions of measurement were. Strong efforts should be made to alter this trend. While the ASTM has an honored tradition of specifying test conditions precisely, this practice has not always been extended to the basic measurements themselves. It is to be hoped that one of the principal research activities in the coming years will be concerned with the effect of the experiment on the specimen and particularly the effect of thermal noise, relaxations, chemical changes, crystal imperfections, etc., in the specimen or the signals which are created to characterize it.



¹ Vice-president, research, Bell Telephone Laboratories, Inc.

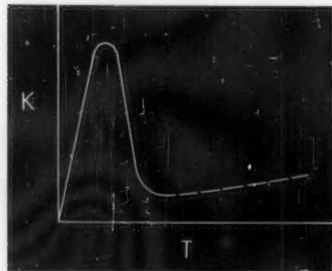
District Activities

SOUTHWEST

The Knowledge-Time Relationship

The Southwest District held three meetings during the week of February 8, two in Houston and one at Dallas-Fort Worth. On Tuesday, February 9, a joint dinner meeting of the ASTM Southwest District and the Houston Section of the National Association of Corrosion Engineers was held at the Houston Engineering and Scientific Society in cooperation with the American Society for Metals, Texas Chapter, and the American Welding Society, Houston Section. About 200 were present to hear ASTM President Frank L. LaQue, vice-president, Development and Research Div., The International Nickel Co., Inc., New York, speak on one of his favorite topics, "What We Know and Don't Know About Corrosion."

"If we plot knowledge against time," said Mr. LaQue, sketching on the blackboard, "when we begin to study a given subject we get a curve that looks something like this:



"As we take the prescribed courses and read the literature and make some studies of our own, we find that very shortly we know just about everything about the topic. Then with a little further study we discover some data that cast doubt on some of our previously known 'facts' and our knowledge drops off rapidly until we find we know little more than nothing for sure.

"Then begins the long slow climb in increasing knowledge as research and study continue. But we rarely reach the point where we know as much about the subject as we did a short while after our studies began." The remainder of Mr. LaQue's remarks were devoted to relating interesting and humorous instances which cast doubt on many of the accepted theories concerning corrosion. Mr. LaQue concluded with a tongue-in-



AT HOUSTON MEETING

Left to right: A. B. Campbell, retired executive secretary, National Association of Corrosion Engineers, and chairman, ASTM Southwest District Publicity Committee; B. B. Manuel, W. H. Curtin & Co., Southwest District Council vice-chairman; ASTM President F. L. LaQue, vice-president and manager, Development and Research Div., The International Nickel Co., Inc.; E. E. Berkley, Anderson, Clayton & Co., chairman, Southwest District Council; and C. B. Tinsley, chairman, Houston Section, National Association of Corrosion Engineers.

cheek remark in which he stated that after his many years of experience in research he has discovered that any data that one might accumulate that contradict common knowledge are useless.

Mr. LaQue was introduced by Allan B. Campbell, publicity chairman of the ASTM Southwest District and retired executive secretary of the National Association of Corrosion Engineers. Dr. E. E. Berkley, Anderson, Clayton & Co., chairman of the ASTM Southwest District, presided at the meeting jointly with the chairman of the Houston Section of NACE.

Student Awards. On February 8, student membership prize awards were presented to students from the University of Houston and The Rice Inst. at a luncheon meeting at the University of Houston. Representatives from the Purchasing Agents Assn., Houston Chamber of Commerce, and the faculties of both schools were invited to witness the presentation of the awards and to hear ASTM assistant secretary F. F. Van Atta speak on "ASTM—A Working Society." He emphasized that the Society's continued successful growth has been brought about by the work of its members and committee members directed toward the common goal of research and standards for materials.

Charles F. Lewis, chairman of the District's student membership prize award committee introduced the awardees, who received their certificates of membership from Mr. LaQue. Awards

were made to ten students from the University of Houston: Tommy Green Cudd, M.E.; Joseph A. Heding, C.E.; Harold G. Keeler, C.E.; Jerry L. Rix, M. W.; Pak Fat Woo, C.E.; Harry S. Parton, C.E.; Robert C. Pendergraft, C.E.; Nelson Strahan, C.E.; Jerome Blaylock, C.E.; and Alfred H. Meyer, C.E.

The eleven students from The Rice Inst. who received awards were: John E. Crider, Ch.E.; Wayne E. Hanson, Ch.E.; Clarence A. Miller, Ch.E.; Robert Joe Bevers, C.E.; Paul Bernard Engelbert, C.E.; Walter P. Moore, C.E.; Rodolfo Ayala-Villarreal, E.E.; Joseph Donald Winslow, Jr., E.E.; Martin Rafael Berkman, M.E.; Bruce Irwin Hendrickson, M.E.; and Paul Leland Key, M.E.

In introducing the students, Mr. Lewis explained that this was only part of the Southwest District's large student membership prize award program. This year a total of 155 awards are being made at 17 colleges in the District.

Dallas-Fort Worth

On Thursday, February 11, Mr. LaQue spoke again at a joint meeting of the ASTM Southwest District held with the North Texas Chapter of ASM and the North Texas Section of NACE at the Howard Johnson Restaurant midway on the Dallas-Fort Worth toll road. An audience of about 100 represented the three societies. The program was arranged by J. Gordon Meek representing the National Association of Corrosion

Engineers, M. J. Condon representing the American Society for Metals, and Edwin Joyce, vice-chairman of the ASTM Southwest District. Mr. Meek presided. Mr. LaQue's discussion of corrosion problems got the same enthusiastic reception that it did in Houston. Questions and answers added substantially to the interest of the program.

NORTHERN CALIFORNIA

Role of Technical Societies Surveyed

"The Technical Man and Technical Societies" was the title of a talk given by A. H. Batchelder, vice-president and general manager of the California Research Corp., at a meeting of the Northern California District, March 3, in San Francisco.

The talk was part of the Student Prize Award program at which 18 students from eight schools in the District received framed certificates and were guests of honor at the dinner meeting. The students were accompanied by six of the professors participating in the program.

OHIO VALLEY

Bates Paraphrases Pericles

ASTM committee work is democracy in action. Through its democratic processes, the Society has developed a body of standards for materials unmatched anywhere in the world. Nowhere else are standards developed under private auspices to the degree they are in the United States and particularly in ASTM. These and other ob-



At the Ohio Valley District Meeting: ASTM Vice-President A. Allan Bates, Portland Cement Assn.; District Chairman R. S. Armstrong, The Standard Oil Co. (Ohio); and F. W. Reinhart, chairman of Committee D-20 on Plastics, National Bureau of Standards.

servations were made by Dr. A. Allan Bates of the Portland Cement Assn. and vice-president of ASTM, speaking before the Ohio Valley District in Cincinnati on March 9. First quoting and then paraphrasing Pericles in statements concerning the Athenian democracy, Dr. Bates said that as a democracy, ASTM expects every member to take an active part; the Society believes that knowledge is a guide to action; there is confidence in frank and fearless

Coming District Meetings

Date	District	Place	Program
April 26	Detroit	Detroit	Speaker: F. L. LaQue
April 27	Central New York	Syracuse	Speaker: A. G. H. Dietz
May 6	New England	Worcester, Mass.	All-Day Program

SOUTHEAST



Head table at January 26 meeting of Southeast District in Atlanta, Ga. Meeting was cosponsored by the local section of the National Association of Corrosion Engineers and ASTM Committee D-19 on Industrial Water.

discussion; the strength of the Society was built up by men who knew their duty and who had the courage to face it.

ASTM's strength derives from the compromise of differences for the common good—emphasized differences required by both producers and consumers meeting face-to-face. Dr. Bates pointed out that ASTM has already lasted longer (60 years) than the Athenian democracy (50 years). ASTM is a symbol of democracy and as long as it can continue to

operate as a democracy, just so long will its strength continue. But constant vigilance is necessary to safeguard the democratic principles that are the strength both of the Society and of the nation.

The district meeting was jointly sponsored by the Ohio Valley District and by Committees D-9 on Electrical Insulating Materials and D-20 on Plastics. The two committees met in Cincinnati during the week of March 7.

Where They Came From!

People Attending Third Pacific Area National Meeting San Francisco, Calif., October 12-16, 1959

OF THE 1301 who registered at the 1959 West Coast Meeting, nearly half were from California, but 42 of the 50 states were represented, as well as five foreign countries. The breakdown:

Alabama.....	7	Nevada.....	7
Arizona.....	5	New Jersey.....	27
California.....	618	New Mexico.....	10
Colorado.....	15	New York.....	67
Connecticut.....	7	North Carolina.....	2
Delaware.....	4	Ohio.....	55
Dist. of Columbia.....	29	Oklahoma.....	15
Florida.....	1	Oregon.....	11
Georgia.....	2	Pennsylvania.....	79
Idaho.....	4	Rhode Island.....	1
Illinois.....	62	South Carolina.....	4
Indiana.....	22	Tennessee.....	9
Iowa.....	4	Texas.....	32
Kansas.....	3	Utah.....	11
Kentucky.....	4	Virginia.....	11
Louisiana.....	2	Washington.....	38
Maine.....	2	West Virginia.....	2
Maryland.....	11	Wisconsin.....	21
Massachusetts.....	19	Wyoming.....	2
Michigan.....	33	Canada.....	16
Minnesota.....	5	England.....	1
Missouri.....	9	France.....	1
Mississippi.....	5	Mexico.....	3
Nebraska.....	2	Venezuela.....	1

Near-Record Committee Week in Chicago

Just over 1400 engineers and scientists—second largest attendance in the history of ASTM Committee Week—worked hard during the week of February 1 to clean up the year's committee work in anticipation of the June Annual Meeting of the Society. In just five days' time, 35 of the Society's technical committees held 351 meetings of subcommittees and working groups whose staggering task it is to keep ASTM standards continually up to date and useful in a fast-changing world. Many of the committee actions are described under Technical Committee Activities, elsewhere in this BULLETIN



AWARD OF CERTIFICATES TO 5000TH AND 10,000TH MEMBER

ASTM President F. L. LaQue (left) presents special certificates to the 5000th ASTM member, Mr. Harold Allen (center), and the 10,000th member, Mr. Robert J. McCallin. Mr. Albert J. Loepsinger, the Society's 1000th member, was unable to attend the Committee Week Dinner, at which the awards were presented.

Dinner Guests Hear Ott On Time-Lapse Photography

THE COMMITTEE WEEK Dinner offered a fascinating interlude to the work week. Not often does one have the opportunity to be socially entertained and intellectually stimulated both in one evening. Yet about 300 persons attending the dinner were so treated to a live-wire program assembled by the Chicago District.

The highlight of the evening was an illustrated talk by John N. Ott on "Time-Lapse Photography." A pioneer and leading authority in the field, Mr. Ott is now a research consultant to General Electric Co., and to Johns Hopkins Hospital. At one time he did work for the Walt Disney Studios.

Illustrating his talk with time-lapse motion pictures, Mr. Ott showed, through experiments in his studio, basement, and greenhouse, how he condensed time to capture nature's full life cycle. He showed the effect that variations in temperature and light have on the growth response of both plants and animals. Mr. Ott told of how he accidentally discovered remarkable variations in the growth response of plants with different types of artificial light. For example, morning glories performed



JOHN N. OTT

Featured Speaker at Committee Week Dinner

much better under one type of fluorescent light than another.

He photographed the growth of a pumpkin under a skylight in his basement and showed that either all-male or all-female flowers resulted, depending on the type of fluorescent light used. This same relationship showed up in experiments with certain types of fish eggs, Mr. Ott revealed. He pointed out that certain normal growth developments can be prevented by filtering cer-

tain narrow energy bands from the full spectrum of natural sunlight.

In summary, Mr. Ott offered the theory that the relationship of growth response to the energy of sunlight carries over into human and animal life. He offered his own belief that light energy taken in through the eyes stimulates certain glands which in turn affect the function of the human machine. Further research may determine how the variation of light energy may be responsible for many mental and physical illnesses, Mr. Ott suggested.

S. R. Wallace of Badall Engineering and Manufacturing Co., Hammond, Ind., and Chairman of the Chicago District, acted as toastmaster for the dinner program. It was announced that the Chicago District is developing a program whereby a panel of lecturers, experts in their various fields, will be available for speaking engagements throughout the Chicago District. These speakers will be available by prearrangement to groups and organizations desiring to keep their members abreast of the current technical knowledge.

Membership Milestones Noted

The Society, which passed an enrollment of 10,000 members last October, gave special recognition to this event at the Committee Week Dinner by presenting a special certificate to the 10,000th member, Mr. Robert J. McCallin, Technical Service Supervisor of the Medusa Portland Cement Co., Wampum, Pa. Turning back the clock, certificates were also given to the 1000th member, Mr. Albert J. Loepsinger, Director of Research, Grinnell Corp., Providence, R. I., who has been a member of the Society since 1908. Mr. Harold Allen, U. S. Bureau of Public Roads, Washington, D. C., also received a certificate as the 5000th member. Mr. Allen joined in 1943. Certificates were presented by ASTM President Frank L. LaQue, vice-president and manager, Development and Research Div., The International Nickel Co., Inc., New York. In presenting the certificates, Mr. LaQue made the following remarks:

"Who will be the next member to receive a similar certificate? There is no evidence of a geometric progression or of a simple arithmetic one. The interval by thousands seems to have been increasing by one the last two times so that the next term in this series would be sixteen thousand.

"The rate of increase has been far from uniform. This was 200 per year for the first five years, 114 per year for the next 35, and 312 per year for the last 16 years. Although we have no right to assume that the most recent rate will persist, we can calculate that, if it should, we would enroll our 16,000th member 19 years from 1959, that is, in 1978. This seems far enough away in the future to make it safe to indulge in this prediction.

"But we are not really concerned with the number of members we have just for the sake of being able to point to a large membership. An increased membership is desirable only to the extent that it is accompanied by a corresponding increase in the effectiveness of the Society for the purpose for which it exists. This result will be certain if the caliber of our membership persists at the high level that has been responsible for the success of the Society up to now. It is evident from the caliber of the 10,000th, 5000th, and 1000th members whom we are recognizing on this occasion that we have been able to maintain the quality of our membership as it has grown in numbers. We can reasonably anticipate that the future product of a large number of members of persistent high caliber will enable the Society to accomplish even more in the years to come than it has achieved in the fruitful years during which its membership has grown to the 10,000 level."

In reply to President LaQue, by letter, Mr. Loepsinger said, "I consider my early decision to join ASTM as one of the wisest I have ever made. At the time, I sported the title of 'Testing Engineer' and the transactions were of great help to me and have continued to be throughout my long career."

Panel Discussion on Appearance of Aluminum Surfaces

Appearance measurement techniques for bare and colored aluminum surfaces are necessary in architectural, automotive, and appliance industries. The work of Task Group 4 of Committee E-12 on Appearance has so far only served to define the enormity and complexity of the problem, was the conclusion of the panel discussion on Appearance of Aluminum Surfaces presented at the Sherman Hotel in Chicago during Committee Week.

Both bare aluminum and material finished mechanically, chemically, or anodically are used in such places as automotive and appliance trim, architectural or building applications, truck trailers, mobile homes, highway bridge railing, and aircraft skin sheet. Variability in appearance in any lot of such aluminum or, for that matter, in any other structural material must be recognized. Advantage can be taken of the variability by suitable design, or its disadvantages can be minimized by proper design.

Commercial instruments that are satisfactory for measuring opaque surfaces are not entirely suitable for anodized aluminum. Nearly all colored anodic coatings are transparent or translucent to some degree, thus producing unique decorative effects. This results in two surfaces to be measured. Other special effects encountered in measuring the color of anodic coatings are directional effects (rolling and die lines), presence of lacquer overcoatings, and color "flop." Available color measuring in-



SOME OF THOSE AT THE HEAD TABLE IN CHICAGO

Left to right: ASTM Senior Vice-President A. Allan Bates; ASTM President F. L. LaQue; Chicago District Secretary C. S. Macnair; Chicago District Chairman S. R. Wallace; and ASTM Past-President and Honorary Member H. H. Morgan.

struments could conceivably be modified to fit the needs for colored anodic finishes.

Gloss, specularity, and numerous related terms define the mirror qualities of a surface when viewed or instrumentally measured under specified geometrical conditions. Methods of measuring the reflectance attributes, definitions of limits, and standards are given. A letter-number designation system for appearance attributes was described.

Panel members were: R. T. Myer, metallurgical manager, Kaiser Aluminum and Chemical Corp., Oakland, Calif.; W. C. Cochran, assistant chief, Finishes Div., Aluminum Company of America Research Laboratories, New Kensington, Pa.; E. F. Barkman, research supervisor, Reynolds Metals Co., Richmond, Va.; and R. V. Paulson, Department of Metallurgical Research, Kaiser Aluminum and Chemical Corp., Spokane, Wash.

Werner von Bergen Named DeWitt Smith Medalist

WERNER VON BERGEN, associate director of research for J. P. Stevens & Co., Garfield, N. J., has been chosen the 1960 recipient of the Harold DeWitt Smith Memorial Medal given by Committee D-13 on Textile Materials. Mr. von Bergen is the 11th recipient of the annual award, which was made on Thursday, March 3, 1960, at the Sheraton-Atlantic Hotel in New York City.



WERNER VON BERGEN

The medal, donated by the Fabric Research Laboratories, Inc., of Natick, Mass., is a testimonial to the memory of Harold DeWitt Smith, who pioneered in the the engineering approach to evaluation and use of textile fiber properties.

Mr. von Bergen has had a distinguished career in textiles beginning with his graduation from the Technical College of Burgdorf, Switzerland, as a chemist in 1916. He served as director

of research for the Forstmann Woolen Co. from 1926 until that firm was acquired by Stevens. Coauthor of the American Wool Handbook and the Textile Fiber Atlas, Mr. von Bergen is also author of the wool and specialty hair chapters of Matthews' Textile Fibers handbook and has more than 50 publications in the field of fiber technology to his credit.

Mr. von Bergen taught woolen manufacturing at Columbia University for ten years. He served as scientific consultant to the U. S. Army in the European Theater during World War II and is at present a member of the Advisory Board on Quartermaster Research and Development of the National Research Council. A member of the U. S. Department of Agriculture Wool Advisory Committee, he served for ten years as chairman of Subcommittee A-3 on Wool and Its Products of Committee D-13.

Active in the Research Council of the American Association for Textile Chemists and Colorists, Mr. von Bergen received that association's Olney Medal in 1952. He is a member of the advisory Council of the Textile Research Institute, a Fellow of the Textile Institute of England, and a Fellow of the Society of Dyers and Colourists of England.

The award was presented by Prof. Benjamin Whittier, chairman of Committee D-13, after an address by Mr. Griffin Ashcroft, textile consultant. Mr. Richard T. Kropf, vice-president of Belding Heminway Co., Inc., and past-president of ASTM, presided.

Technical Committee Notes

To our technical committees falls the monumental task of keeping the more than 2600 ASTM standards up to date. To do this, and also to supply the ever-growing stream of new standards that are needed by a fast-moving industry, the committees conduct a vast body of continuing research into the properties of materials. During Committee Week in February, many committees meet to put their work into the form of recommendations to be presented at the Annual Meeting in June. A sampling of recent activities of these committees is given in the following pages. Actions on standards are subject to letter ballot in the respective committees and, for the most part, will be reported to the Society in June.

Metals

New Specifications Coming for Zinc and Aluminum Coatings

A new specification covering zinc-coated (galvanized) iron or steel sheets for culverts and underdrains has been completed by Committee A-5 on Corrosion of Iron and Steel. Work is continuing on specifications for aluminum-coated iron and steel sheets.

A new atmospheric exposure test program covering galvanized and aluminum-coated steel corrugated roofing sheets is being assembled. Exposures will be made this spring at five exposure sites throughout the United States.

Premature appearance of matte finish on galvanized surfaces was discussed. The data presented indicate that discoloration or the lack of glossy finish is more a result of variations in applying the coatings rather than the use of improper materials.

Laboratory work was reported on test methods for porosity and uniformity of aluminum coatings. Methods of analysis of aluminum coatings were initiated.

Considerable interlaboratory work was reported on two alternate methods (using NaOH-HF and HCl-SbCl₃) for stripping aluminum-coated articles in order to determine the weight of coatings. The data presented indicated that neither method is entirely satisfactory and therefore they will not be recommended for inclusion in the Method of Test for Weight of Coatings on Aluminum-Coated Iron and Steel Articles (A 428).

Low-Carbon Grades Added to Stainless-Steel Specifications

An action which has been eagerly awaited by industry—the addition of low-carbon grades of stainless-steel cast-

ings to Specification A 296—was approved by Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys. Grade CF-3 will cover the low-carbon chromium-nickel composition, and grade CF-3M the low-carbon chromium-nickel-molybdenum steel. Other new grades will also be added to Specification A 296, including CG-8M, HD, HL, and HN.

Complete 15-Year Atmospheric Exposure Program

In 1941 Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys initiated an atmospheric exposure program to determine the galvanic effects of various metals, including aluminum, when contact-coupled to types 304 and 316 stainless steels. Following 15 years of exposure, the final specimens were recalled and tested. The data are now complete and an evaluation committee was authorized to prepare the final report.

The first draft of the copper-accelerated acetic acid salt-spray (fog) test was submitted for subcommittee action. Revisions of Method B 287 were also presented that will be helpful in case impure salt is used in the method.

Further work on time-of-wetness and sulfur dioxide measurements was reported. The apparatus developed by P. J. Sereida¹ has amassed more than one year's data, and additional instruments will be assembled to collect data at two exposure sites in Canada and four sites in the United States, on time-of-wetness, presence of SO₂ while wet, and specimen temperature.

The comprehensive study of the relative corrosivity of atmospheric exposure test sites to zinc and steel will be started

¹"Measurement of Surface Moisture," ASTM BULLETIN, February, 1958, p. 53; May, 1959, p. 61.

this spring at 39 test sites covering the Philippines, Canada, England, the Panama Canal Zone, and the United States.

A task group to develop an internal exposure test of a variety of water-tube materials in a standby heat exchanger is soliciting interest in this field. Interested parties should get in touch with Mr. Frank Kahn, 900 Sansom St., Philadelphia 5, Pa.

ASTM To Use Aluminum Assn. Designations for Wrought Alloys

ASTM specifications for wrought aluminum and aluminum alloys will now identify those alloys by the Aluminum Assn. designations. Although the ASTM system for identification was established before the Aluminum Assn. system, the latter has been accepted as the industry standard. For several years the ASTM specifications have identified each alloy by both systems. For cast aluminum alloys and for both cast and wrought magnesium alloys, the ASTM system will be continued.

The chemical industry will at last have an industry-wide specification under which aluminum and aluminum-alloy wrought welding fittings can be purchased. This specification was approved by ASTM Committee B-7 on Light Metals and Alloys, and will be recommended to the Society for publication at its Annual Meeting in June.

Anodizing Draws B-8 Attention

Committee B-8 on Electrodeposited Metallic Coatings acted to enlarge its scope and title to include anodized and functional coatings. The proposed new title: "Electrodeposited Metallic Coatings and Related Finishes."

The subcommittee on anodizing drafted a recommended practice for sulfuric-acid anodizing of aluminum for various applications, resubmitted the proposed specification for anodic coatings on aluminum and aluminum alloys with an appendix indicating the various features necessary for these uses, and revised Method B 136 on sealing of anodic coatings. A method of testing the thickness of anodic coatings using the eddy-current test is being developed.

A specification for multilayer nickel and chromium electroplating on steel is being submitted for subcommittee ballot. This new development in the

plating industry has received wide application, particularly in the automotive field. Similar specifications on zinc-base die castings are being developed. A new code for designating coating thickness has also been developed.

Grain Sizes Transparencies to Be Offered

Transparencies of the 22 grain sizes now included in Plate I of Method E 112 for Estimating the Average Grain Size of Metals will be offered for sale by ASTM Headquarters. Committee E-4 on Metallography feels that such transparencies would serve the metal industry as a useful tool. Plate I covers untwinned grains with a flat etch and is particularly applicable to aluminum, magnesium, zinc, and ferritic iron and steel at a magnification of 100 \times . However, the committee feels that the transparent simple grain network could also be used to estimate grain size of other metals more easily than could transparencies of the standard twinned and contrast-etched grain sizes in the other plates of Method E 112.

Since its issuance in 1955, Method E 112 has called attention to four charts of the various types of metallic grain structures available for a comparison procedure for estimating grain size. Many difficulties have plagued the preparation of Plate II for twinned grains with a flat etch, particularly applicable to nickel and nickel-base alloys, stainless steels, and various other alloys. However, this work is progressing and the chart should be available in 1960.

A very extensive manuscript has been written by a task group describing the powder diffraction procedures for chemical analysis and the application of the powder diffraction card file sold by ASTM for the Joint Committee on Chemical Analysis by Powder Diffraction Methods. The only presently published ASTM document on the same subject is the Recommended Practice for Identification of Crystalline Materials by the Hanawalt X-Ray Diffraction Method (E 43). It is intended, after a review of the manuscript by the editors of the card file, to have ASTM issue this material as a Special Technical Publication (STP). Recommended Practice E 43 will be withdrawn and a new recommended practice based on the STP will be published in the ASTM Book of Standards.

Construction Materials

Expanded Scope Seen for Committee C-3

A suggested expansion of scope to include membranes and linings was received with considerable interest at the meeting of Committee C-3 on Chemical-

Resistant Mortars, held at the Midway Motel, Cleveland, Ohio, February 25 and 26. Such an expansion might include monolithic floor surfacing compounds, troweled-on tank linings, bed joints, grouts, and latex-cement mortar. A study group will provide suggestions for a revised title and scope. It was felt that a real need existed for standards to cover a larger market and that ASTM should keep ahead of the field.

A new method of test for flexural strength of chemical-setting silicate type chemical-resistant mortars was approved for committee letter ballot. Research on the modulus of elasticity of various types of chemical-resistant mortars using sonic, flexural, and compressive methods has shown agreement between flexural and compressive test results but not with the sonic method. Further tests will be conducted with the sonic method using smaller specimens. Data on thermal expansion tests to date have shown favorable results for silicates and resins but not for sulfur. A second series of tests will be conducted to establish better reproducibility.

All present tentative recommended practices were approved for adoption as standard with minor revisions. Revisions in the Specification for Resin-Type Chemical-Resistant Mortars (C 395) were approved, subject to letter ballot; a chemical-resistance requirement will be added to Table I. No definite limits were set, however; limits will be mutually agreed upon between consumer and supplier.

Lime on the Farm

The use of lime and limestone in agriculture received considerable attention from Committee C-7 on Lime. A new subcommittee was authorized to study the need for standards for agricultural liming materials. This subcommittee will start as a study group, since it was recognized that both the materials and the requirements in the agricultural field are quite varied throughout the country.

The use of limestone in the chemical and processes industries also received attention. A special task group set up to study both agricultural and chemical uses reported that there is now no need for specifications, but a subcommittee was formed to watch the area and to be prepared to make recommendations as any need develops.

Tapes, Adhesives for Gypsum Wallboard to Be Standardized

Accessories used in gypsum plaster construction may be as important to a successful structure as the basic materials. A proposed specification for joint tape and adhesive was reviewed at the meeting of Committee C-11 on Gypsum. Final action is expected at the next meeting. Another accessory, nails for use with gypsum wall board, has been

covered by ASTM Specification C 380. Further revisions to this specification were approved, subject to committee letter ballot.

In order to facilitate the use of the ASTM Methods of Tests for Gypsum and Gypsum Products (C 26), the committee will separate the methods into three standards covering chemical analysis, physical tests, and general tests.

Test for Organic Fiber Content Moves Toward Approval

The determination of organic fiber content of asbestos-cement products has been a difficult problem. A proposed method of test under consideration for some time was approved for letter ballot at the meeting of Committee C-17 on Asbestos-Cement Products held in New York City on Feb. 17 and 18. Dissatisfaction has been expressed with the present alkalinity test procedure in the Specification for Asbestos-Cement Non-Pressure Sewer Pipe (C 428). A proposed method of test for uncombined calcium hydroxide to measure the chemical stability of pipe was accepted, subject to subcommittee letter ballot. Additional test data covering an acid solubility test method will also be submitted for review.

Agreement was reached to separate all methods of test from the existing specifications for asbestos-cement roofing shingles, siding shingles and clapboards, and flat sheets. These procedures will be issued under a separate ASTM designation to eliminate duplication of printing. A similar standard was approved to include all methods of tests which now appear in the two specifications for pipe (C 296 and C 428). The Specification for Corrugated Asbestos-Cement Sheets (C 221) will continue to contain its own test procedures.

A number of changes were approved in the specifications for: flat asbestos-cement sheets (C 220) ($\frac{1}{8}$ - and $\frac{3}{8}$ -in. thicknesses were added), asbestos-cement roofing shingles (C 222), asbestos-cement shingles and clapboards (C 223) (completely rewritten), and asbestos-cement pressure pipe (C 296). The need for definitions of terms relating to asbestos-cement and related products has been evident for some time. The first effort to establish a list of such definitions was reviewed and accepted for committee letter ballot.

D-4 Eyes Precision of Tests

Precision of test methods keynoted the discussions of many of the subcommittees of Committee D-4 on Road and Paving Materials. As a result, an *ad hoc* committee was authorized to study precision limits in all methods of test under the jurisdiction of the committee. Allied to this was the expressed need for standardization and refinement of ovens used in the testing

of bituminous materials. A second *ad hoc* committee was authorized to study this subject.

The growing use of microviscosimetry equipment prompted an interesting round-table discussion on the subject. It was felt that the discussion will help in the preparation of better methods of test and a better understanding of the equipment, some of which was on display.

Considerable activity in extraction and recovery methods was reported: a proposed method for the recovery of asphalt by the Absen Method is now being considered by the proper subcommittee. Four methods for extraction have been distributed as information, the objective being to arrive at one standard method for extraction and one for recovery of constituents from bituminous mixtures. A proposed ring-and-ball test method for tar and tar pitches received minor revisions and was authorized for publication in the ASTM BULLETIN. A proposed method for stone coating and water resistance was approved for committee letter ballot subject to subcommittee confirming letter ballot. The thin-film test is continuing to receive attention, with a new test program organized in which twelve members will participate using three samples of asphalt cement, one sample of blown asphalt, and one sample of tar pitch.

Tests for Wood Fasteners Nearing Approval

The development of standards for mechanical fasteners is one of the newest activities in Committee D-7 on Wood, which held its annual meeting at the U. S. Forest Products Laboratory on January 21 and 22 at Madison, Wis. Three proposed methods of test in this field were approved, subject to confirming letter ballot. The first will provide a procedure for evaluating the strength and rigidity of bolted timber joints using metal connectors. The second is a basic procedure for evaluating the resistance of wood and wood-base materials to direct withdrawal of screws. The third method is a lateral nail or a screw resistance test for determining the resistance to lateral movement offered by a single nail or screw in wood members. This method will provide comparative data for various species of wood.

Also under development are methods for testing strap hangers for joists, testing flooring, determining specific gravity (this will go beyond the present two methods now covered in ASTM Standards), statistical sampling of small clear specimens, and testing plywood in large-size elements.

A second method of test to measure durability and the effect of exposure, "Proposed Method of Testing Wood

Preservatives by Field Tests with Stakes," was approved for letter ballot. Revisions of the first method of this type, the Method of Testing Wood Preservatives by Laboratory Soil-Block Cultures (D 1413), are being considered.

The committee reviewed a proposed method for charcoal analysis, which will be particularly adaptable to the evaluation of products from wood charcoal kilns.

A dinner meeting and program was arranged by Chairman Markwardt, with a very good attendance of committee members and guests.

New Group on Industrial Pitch

A new subcommittee on industrial pitches was formed at the meeting of Committee D-8 on Bituminous Materials for Roofing, Waterproofing, and Related Building or Industrial Uses. This is an expansion of the area of interest of the committee to cover a material whose properties and characteristics differ from those of bituminous roofing and waterproofing. The new subcommittee will develop methods of test for measuring properties of industrial pitches that are important to its performance both in processing and in end use. Task groups were appointed to seek available test methods that might be satisfactory or might be developed further to measure such properties as softening point, specific



This is one of a series of photographs from a collection compiled by Prof. Jasper O. Draffin and displayed in the Arthur N. Talbot Laboratory, University of Illinois.

CHRISTIAAN HUYGENS (1629–1695). Born in Holland, Huygens constructed large telescopes and improved lenses, and in 1656 invented the pendulum clock. Huygens also expounded the wave theory of light. His greatest book, *Horologium Oscillatorium*, appeared in 1673, and formed the basis of our present theory of dynamics. Huygens was the first to write on dynamics of rigid bodies.

"It is always possible to attain . . . to a degree of probability which very often is scarcely less than complete proof. To wit, when things which have been demonstrated by the Principles that have been assumed correspond perfectly to the phenomena which experiment has brought under observation; especially when there are a great number of them, and further, principally, when one can imagine and foresee new phenomena which ought to follow from the hypotheses which one employs, and when one finds that therein the fact corresponds to our prevision."

Treatise on Light

gravity, insolubles, distillation, coking value, ash and sulfur, and wettability. Other properties proposed for consideration were: C:H ratio, viscosity, aromaticity, graphitizability, penetration, weathering, water absorption, chemical resistance, water content, and molecular weight.

Proposed specifications for both homogenous and laminated bituminized fiber pipe were approved for subcommittee letter ballot. One of the newer materials used in built-up roofs is glass fabric. A proposed specification for glass fabric saturated with bituminous materials was accepted for subcommittee letter ballot. Progress was reported in the rather difficult field of rheological properties, with test programs under way on pliability or brittleness, and flow under low stress.

Small-Scale Fire Tests Win Approval

So-called "small-scale" test methods to determine flame-spread characteristics for developmental and research purposes only were recognized by Committee E-5 on Fire Tests of Materials and Construction. The radiant panel test method, developed at the National Bureau of Standards, was approved for letter ballot and presentation to the Society as a new tentative method. This method has received rather wide recognition and is presently being considered as an approved method in Federal specifications. The introduction and scope of this method will emphasize that it is not intended for use by building code authorities to establish ratings of materials. The smaller 8-ft tunnel test developed at the U. S. Forest Products Laboratory, as part of a research project sponsored by Committee E-5, also was recognized to the extent of approving its publication as a proposed method of test in the annual report of the committee. With only one installation of this equipment existing at present, it was felt inadvisable to recommend this method as a new ASTM tentative at this time.

Changes were approved in the standard fire test method, E 119, long recognized by building code authorities as a rating test. The changes relate to the conditioning of test specimens and the height of simulated attic space above ceiling assemblies. These revisions, previously published as tentative revisions, will now be incorporated into the standard. The method of test commonly referred to as the "tunnel test" for measuring flame-spread characteristics (E 84) was approved for adoption as standard.

E-6 Plans New Subcommittee on Curtain-Wall Construction

Curtain-wall construction is now playing a very prominent part in modern

buildings. The problems of evaluating the performance as well as the significant characteristics of this type of construction are well recognized. Committee E-6 on Methods of Testing Building Constructions is considering the organization of a new subcommittee on curtain-wall constructions.

Closely related to curtain-wall construction as a building component are window assemblies. To avoid an overlap of interest with curtain-wall construction the scope of the new subcommittee on window assemblies will be limited to cover operable window assemblies only. Seven task groups were established to consider the following aspects: structural performance, air infiltration, water leakage, thermal performance, hardware, definitions, and collection of existing performance requirements and methods.

As the result of a reorganization of the subcommittees concerned with structural properties, structural testing within the committee will now be divided into three main areas: (1) segments of walls, floors, and roofs; (2) structural elements such as trusses, beams, and columns; and (3) completed buildings.

The Standard Methods of Conducting Strength Test of Panels for Building Construction (E 72) will be clarified and simplified in order that the separate test procedures may have greater recognition. A lateral nail holding test is under consideration. All reference to the term "panel" will now be changed to the term "segment." The Standard Methods of Testing Truss Assemblies (E 73) will be clarified for use by building code officials.

Recognizing that standards to evaluate durability of building constructions would be practical only in the form of recommended practices, a British recommended practice is being reviewed. In the field of unit masonry, a research method to determine water penetration of masonry, already circulated to the subcommittee, will be sent to all committee members. A test program is under way at the Forest Products Laboratory on four materials used as vapor barriers, using the new ASTM Methods of Test for Materials for Use as Vapor Barriers under Concrete Slabs and as Ground Cover in Crawl Spaces (E 154). Alternate methods prescribed by the Federal Housing Administration will also be included in the test program.

Ceramics

Corrosion and Erosion of Glass Tank Refractories

A new activity in Committee C-8 on Refractories is development of methods for determining alkali corrosion of glass

tank refractories. Static and dynamic tests applicable to the erosion of glass tank refractories at the "metal" line in glass furnaces are now being studied.

A method for chemical analysis of silicon carbide brick and a method for determining the resistance of carbon refractories to disintegration from alkalis (a blast furnace problem) were submitted for Society action.

A new classification for chrome, chrome-magnesite, magnesite-chrome, and magnesite brick (excluding electrically fused products) will be presented to the Society. Classifications for mulite brick and granular dolomite were completed for committee action. Classification for silicon carbide brick and zircon brick are being developed.

Work on extending the temperature range of pyrometric cones was announced. Four new PCE cones above cone No. 42 are being calibrated with a maximum temperature of about 2600 C.

Porcelain Enamel Continuity, Spalling Resistance Tests

Two new methods were presented at the meetings of Committee C-22 on Porcelain Enamel; one is a method to determine the continuity of coating (absence of pinholes), the other is a test for spalling resistance of porcelain enamel on aluminum. The latter method evaluates the adhesion of the porcelain-enamel coatings on aluminum and aluminum alloys when immersed in a 5 per cent ammonium chloride solution. There have been no authenticated cases in which properly tested specimens passed this test and subsequently spalled in service.

Tests for impact strength, coefficient of thermal expansion, and stress-strain analysis of porcelain enamels were reported in various stages of completion.

Electrical and Electronic Materials

Density Relation Set for Iron-Aluminum Alloys

In measuring the magnetic properties of sheet metals used for magnetic core materials, a more accurate method than direct measurement for determining cross-sectional area of test specimens is to calculate the value from measured length, weight, and known density. For this purpose, composition-density tables for the alloys under test are useful. A task group of Committee A-6 on Magnetic Properties has reached agreement on the density-composition relationship for iron-aluminum alloys as shown in the accompanying table. It was recommended that the committee take immediate steps to revise the Methods of Testing Magnetic Materials

Aluminum Content of Iron-Aluminum Alloy, per cent	Density, g per cu cm
0.....	7.85
2.....	7.63
4.....	7.42
6.....	7.22
8.....	7.04
10.....	6.89
12.....	6.75
14.....	6.64
16.....	6.54

(A 34) to incorporate this table. This will then supplement similar data on iron-silicon, iron-nickel, and other alloys presently included in Methods A 34.

In arriving at its agreement on the iron-aluminum data, the task group had surveyed the literature and found that data had been published in 1934 by Sykes and Bampfyld.¹ Accuracy of the data was corroborated by tests in six laboratories of task group members. Results for the most part were within 0.2 per cent of the published data, with the largest deviation being 0.8 per cent.

The committee also reported progress in preparing a Manual of Magnetic Testing, which it expects will be a useful adjunct to the standard test methods for magnetic materials appearing in Part 3 of the ASTM Book of Standards.

Help Needed on Thermostat Metals Bibliography

The Committee on Metals for Thermostats and for Electrical Heating, Resistance, and Contacts (B-4) is preparing to publish a bibliography and abstracts on thermostat metals which it intends to keep up to date with regular supplements. This will be the second such bibliography sponsored by the committee; it has long sponsored the electrical contacts bibliography (*STP-56G* and Supplements). The committee is using all available sources, the most useful so far being the 1947 ASME Bibliography on Thermostat Bimetals, Low Expansion Alloys, and Their Applications. The committee wants this first edition of the bibliography to be as complete as possible and asks help from anyone who may have collections of references on this subject. Communications should be addressed to U. U. Savolainen, Manager, Materials, Process, and Product Standards Specifications, General Plate Div., Metals and Controls Corp., Attleboro, Mass. Mr. Savolainen is chairman of the Thermostat Metals Subcommittee.

Committee B-4 this year will co-sponsor the Annual Seminar on Electrical Contacts to be held at the Pennsylvania State University in June. A review committee for papers has been formed from the B-4 membership.

Companies interested in wire for wire-wound resistors will be able to specify requirements for a number of

different resistance alloys and for temperature limitations of enamels by reference to a completely revised specification on wire for wire-wound resistors expected to be approved by the Society later this year. The old Specification B 267 covered only a single alloy type. The requirements for enamel coatings are being coordinated with the magnet wire subcommittee of Committee D-9 on Electrical Insulating Materials. While the requirements for enamels for magnet wire are somewhat different from those for resistance wire, the same types of enamel are used and there are points in common in establishing the specification requirements for such coatings.

Thermostats for Carburetors. Nearly completed is a test method for measuring mechanical torque rate of thermostat metal coils. Heretofore, torque rate has been measured in various ways, giving rise to problems of communication between buyers and sellers of such coils. While the largest application for thermostat metal coils is in the automatic choke for carburetors, the test can be used for evaluating this same property of other types of springs. It will provide a more consistent way of reporting data on this type of test.

Dust and Fog Tracking Tests Get Critical Review

The tendency of organic electrical insulations to carbonize or "track" and cause failure has long been a problem, especially outdoors where materials become fouled with dirt and moisture. For several years the electrical industry, through ASTM Committee D-9 on Electrical Insulating Materials, has worked toward standardization of a laboratory test that would evaluate the resistance of materials to tracking under dust and fog conditions. The best efforts of the committee were published as a Suggested Method in 1957. This test has been tried out by a great many companies, both in this country and abroad, and a number of improvements have been suggested. The dust and fog tracking test and similar tests developed both in this country and abroad were given a thorough review at the Cincinnati meeting of Committee D-9 early in March. Leading the discussion was Kenneth Wechsler of Westinghouse. G. M. L. Sommerman of Westinghouse presented results of laboratory tests using the published dust and fog test with several modifications. W. I. Weiss of Transistor Devices spoke on dust and fog test equipment. G. R. Mitchell of the Glastic Corp. discussed acceleration of wet tracking tests and, finally, K. N. Mathes of General Electric discussed a tracking test based on a test developed in Norway and published under the auspices of the International Electro-technical Commission. The consensus

was that the tests were useful, but all seemed to lack something either in reproducibility or in the ability to evaluate all grades of materials, especially those that are highly resistant to tracking. Several of the tests under consideration, however, will rate a group of materials in the same order of merit. The objective from all this work is to establish an ASTM standard test that will be widely applicable and useful.

Thermal Stability. The committee had recommended publishing as information two methods for evaluating thermal stability of coated fabrics by the use of curved electrodes, one a dielectric-breakdown method and the other a dielectric proof test method. These two methods appeared in the October, 1959, edition of ASTM Standards on Electrical Insulating Materials as Appendices III and IV. The committee now has evidence that the dielectric-breakdown method is superior to the proof test method and has recommended that the latter method be withdrawn.

The committee elected officers for the two-year term, beginning after the Annual Meeting, as follows: A. H. Scott, chairman; E. B. Snyder, vice-chairman; T. Hazen, secretary; and J. R. Taylor, membership secretary.

Dielectric Strength Test To Be Improved

One of the most important properties of electrical insulation according to many experts, is the voltage level it can sustain without breakdown or excessive heating or deterioration. A measure of this voltage is given by the standardized test for dielectric strength, and there have been on the Book of Standards for a number of years methods D 877 for measuring dielectric strength of insulating liquids. These methods use circular-disk metal electrodes; the electric field between such electrodes is likely to be nonuniform because of their shape. Committee D-27, at its meeting in Washington, D.C., on Feb. 23, reported the completion of an extensive series of interlaboratory tests to evaluate the German VDE test for testing the dielectric strength of liquids. An outstanding feature of this test is the use of curved electrodes which provide a more uniform electric field. Results of the extensive tests prove the superiority of this type of test for evaluating dielectric strength of insulating liquids, and steps are being taken to establish a procedure based on the VDE test as an ASTM tentative.

The committee will submit for publication by the Society later this year a recommended practice for estimating relative temperature limits of dielectric liquids, a method for sampling askarels (synthetic nonflammable insulating liquids), a test for volume of oil in oil-

¹ C. Sykes and J. W. Bampfyld, *J. Iron & Steel Inst.*, Vol. No. 130, No. 389 (1934).

contaminated askarels, and methods for specific gravity and free chlorides in askarels. Free chlorides are objectionable in askarels because as ions they contribute to lower insulating values, thereby causing losses. This method is very sensitive and reveals the presence of free chlorides in amounts as low as one part per million.

Cooperation with AIEE. Cordial cooperation and liaison continues with the Insulated Conductor Committee of the AIEE. In the past few years, Committee D-27 has developed tests relating to cable oils which the AIEE Committee had indicated were needed. The AIEE has asked Committee D-27 to develop tests for volatility of constituents of cable oils, and to this end a section has been established in the D-27 subcommittee on physical tests. However, there is yet some question as to what the needs are for such a test in terms of cable oil performance, and additional information from AIEE on this point is being sought.

F-1 to Adopt Metric System; Waging Mills-to-Microns Battle

The electron-tube industry now weighs fine wire in grams and measures its length in centimeters and meters but, curiously, measures its diameter in decimal inches. This is one of a number of examples of odd mixtures of English and metric units in the electron-tube industry. At its meeting in Washington, D. C., on Feb. 26, Committee F-1 on Materials for Electron Tubes and Semiconductor Devices placed itself on record as favoring the gradual adoption of the metric system as the primary system for its standards. The committee will gradually introduce into its standards metric measurements, giving the English equivalents in those cases where English units had been used previously. One stumbling block is the problem of the size of metric units for conversion. For example, one mil is equal to 25.4μ according to the established conversion factor. In specifying, say, 5-mil wire, there is the question of whether the conversion should be 127μ , which is the exact conversion, or some rounded-off value, say, 130μ . Measuring instruments may be quite satisfactory for measuring to prescribed tolerances in ten thousandths of an inch but would not be able to measure to an unrounded-off exact metric equivalent. As a solution, the committee has prepared a conversion table giving rounded-off equivalents, which it is studying. It is also investigating the various standards available covering conversion tables and preferred numbers.

Strip. The committee is developing a test for measuring burr, which is objectionable for the fine tolerances used in electron tubes. It is also

interested in measuring thermal emissivity and would be interested in activities of other groups concerned with the same problem. This is one of the thermophysical tests that have been under discussion from the Society-wide point of view recently in Committee E-1 on Methods of Testing.

Wire. Specification F 290 for grid laterals will soon be extended to cover smaller sizes of tungsten and molybdenum. Some difficulty has been experienced with adhesion of gold plating on grid lateral windings where gold is plated over a nickel flash coating. The committee is investigating the proper amount of nickel needed to obtain adherence. The specification covering nickel wire for lamps (F 175) is being re-evaluated through a canvass of the lamp industry to determine what changes, if any, are needed.

Semiconductors. Only a few parts per billion of boron in silicon can be objectionable. Such tiny amounts are beyond the limits of present chemical methods, and present efforts are toward developing a method for analysis of boron in silicon by a floating-zone crystal-growing technique.

Methods for resistivity and lifetime of germanium and silicon have been drafted. There is joint activity with the Institute of Radio Engineers and the American Institute of Electrical Engineers on lifetime measurements, and there is very good liaison with these other societies so that each can take advantage of the others' progress. A task group is investigating methods for measuring mobility of charge carriers of particular interest in connection with intermetallic semiconductors (GaAs, PbTe) of current interest in thermoelectric applications.

Control of Contaminants. While this subject is of great interest in the electron-tube and semiconductor industry, it is also of interest to other industries such as the drug and fine machinery industries. The make-up of the subcommittee shows this, as there are a number of members from other than the electronic industry active in the committee's work. About six methods of test have been drafted covering the purity of cleaning reagents and the cleanliness of surfaces and environments.

Organic and Polymeric Materials

New Methods Prepared for Chain Length, Intrinsic Viscosity of Cellulose

At a February 23 meeting in New York, Committee D-23 on Cellulose and Cellulose Derivatives proposed that the method for determination of cellulose chain length uniformity by fractional precipitation of cellulose

nitrate be published by the Society. This method converts the cellulose sample into cellulose nitrate, and, by separation of the nitrate into several viscosity components, the measurement of the weight and viscosity of each recovered fraction is used to calculate the average chain length (degree of polymerization).

The committee also presented a method of test for intrinsic viscosity of cellulose for publication. In this method the sample is dissolved in cupriethylenediamine hydroxide solution, and the viscosity of this solution is determined by means of a calibrated glass capillary-type viscometer.

The ethanol-benzene method for determination of waxes, fats, resins, etc. soluble in that solvent will also be presented to the Society for publication.

A method to determine the disperse viscosity of cellulose has been drafted. Standard cellulose samples are being sent to six laboratories for an evaluation of this test.

Research work in past years has indicated the importance of the carboxyl and carbonyl groups in cellulose. The committee is now collecting data from an interlaboratory study of six methods to determine the carbonyl groups in cellulose. Most of the methods agree quite well. A paper is being prepared reviewing the statistical evaluations of the data. A method for determination of the carboxyl groups is also being prepared.

A new method to determine the degree of substitution of sodium carboxymethylcellulose was announced.

Tests for Casein Quality Revised

Seven chemical methods for characterizing casein, covering free acidity, oil content, ash, fixed ash, nitrogen, moisture, and total fat, have received minor revisions at the hands of Committee D-25 on Casein and Similar Protein Materials in final preparation for presentation to the Society. In the works are test methods for heavy metal analysis, and bacteria and mold content of casein.

Further cooperative tests were approved for eight physical test methods that were presented at the previous meeting.

The committee is studying definitions for common industrial terms in the casein and soy protein field.

Coal, Chemical Products, and Water

Progress on Specifications for Mechanical Sampling of Coal

Specifications for mechanical sampling of coal and for preparation of coal

samples for analysis are well along in committee D-5 on Coal and Coke. A development of this project has resulted in the formation of a new subcommittee on statistics.

The method of test to determine the relative plastic behavior of coal when heated under prescribed conditions in the absence of air using the Gieseler coal plastometer was approved for presentation to the Society.

Further work on broadening the coverage of methods of analysis of coal has resulted in new methods for sulfur in coal ash, determination of mineral carbon dioxide, and ash fusibility.

Delegates to the meeting of Working Group 8 on Testing of Coke of ISO/TC 27 reported the program and progress as regards presentation of American test methods for acceptance by ISO. The committee plans to send a delegate to the next ISO meeting covering this activity.



MEMBERS AND GUESTS OF COMMITTEE D-23 ON CELLULOSE AND CELLULOSE DERIVATIVES AT THE COMMITTEE'S FEBRUARY MEETING IN NEW YORK.

Styrene Monomer Standards Developed by Committee D-16

The development of standards for styrene monomer was reported at the meetings of Committee D-16 on Aromatic Hydrocarbons. Methods prepared for interlaboratory testing include inhibitor and aldehydes in styrene monomer, polymer content, and solubility of styrene monomer.

Tar acid test methods that have been prepared for interlaboratory testing cover determination of oil and naphthalene, distillation range, specific gravity, water content, and solidification point.

Interlaboratory work is continuing on the phenol assay using the bromate-bromide technique. The Durex cloud-point technique for determining the water solubility of phenol is also being subject to interlaboratory tests. The proposed specifications for refined phenol are being circulated to the subcommittee for approval.

Standard samples of phthalic anhydride are being prepared for measurement of heat stability and color of melt. Standardization of the apparatus for these tests is also under study.

Four methods for determination of trace sulfur in aromatic hydrocarbons are under consideration.

Solvent Survey Shows Vapor Toxicity, Flash Point Are Major Problem Areas

A survey of some 600 companies by Committee D-26 on Halogenated Organic (Cleaning) Solvents gave problems of vapor toxicity and flash point highest priority among a number of matters needing attention in the field of cold cleaning. Both petroleum and halogenated solvents are involved, either straight or in mixtures. The survey showed the following items to be of interest, in the order listed:

Vapor toxicity	Electrical conductivity
Flash point	Dermatitis
Evaporation rate or drying time	Odor
Residue	Cleaning ability
Corrosiveness	Specific gravity
Boiling point or range	Explosiveness of vapors
Solvent action on insulation	Refractive index
	Acidity or alkalinity

The test methods subcommittee, taking its cue from the expressed interests of industry as shown by the survey, is concentrating its efforts on tests for properties near the top of the list. Present ASTM methods will be reviewed for applicability. The cold cleaning subcommittee, which conducted the survey, will establish criteria for use of solvents so as to provide a basis for meaningful test methods.

The vapor degreasing subcommittee is preparing a manual on use of solvents in vapor degreasing, which will also provide a basis for test methods.

The committee elected the following officers to serve for the next two years, with terms beginning after the 1960 Annual Meeting:

Chairman: W. D. McMaster, General Motors Corp. Vice-chairman: G. M. Ford, Bendix Aviation Corp. Secretary: (Mrs.) Wanda Campbell, Vego Chemical Corp.

Industrial Chemicals Committee Tackles Ambitious Agenda

Tests for heavy chemicals—acids, alkalies, etc.—are getting an industry going-over for practically the first time in the history of the chemical industry as

musty files are brushed off and procedures bared through an anonymous survey conducted by the fledgling Committee E-15 on Industrial Chemicals. For the first time, companies are learning how other companies titrate sulfuric acid against standard alkali for strength determination. Some are surprised to learn that their laboratories have not updated procedures in recent years as improved techniques are published. All this is a prelude to the establishment of some standard methods for testing industrial chemicals.

Standardization of test methods for chemical products is only one of the many tasks the committee has set for itself. It is reviewing available literature and methods for determining the elements, starting with chlorine and sulfur, in organic compounds, and for determining functional groups—hydroxyl and unsaturation; and it is preparing to develop extensive temperature-density tables for organic liquids and later for other chemicals in liquid form. The committee is also working on physical methods such as melting and freezing points and is reviewing the many ASTM methods for water determination using the iodine reagent (Karl Fischer) method. The objective here is to prepare a general method to which the technical committees can refer, thus reducing much duplication of nearly identical procedures in the Book of Standards.

E-1 Subs to be Transferred. With approval of Committee E-1 on Methods of Testing, subgroups on determination of water and on correlation of chemical analysis will be transferred to Committee E-15.

To Publish Statistical Definitions. Statisticians and would-be statisticians can add another document to their files on precision, accuracy, and other like terms with the publication this year of the annual report of the committee. Definitions approved by the subcommittee on precision and accuracy will be published as information appended to the report.

Gas Chromatography a Live Subject. The committee discussed a proposal by Prof. M. K. Testerman of University of Arkansas for organizing activity in ASTM on gas chromatography. It was felt that the subject might be too broad for a subcommittee of E-15 and a separate committee may be indicated. The matter will be taken up with other administrative groups in the Society.

High Purity, Heavy Water, Radioactivity Measurement Occupy Water Committee

At the January, 1960, meetings of Committee D-19 on Industrial Water, in Atlanta, Ga., work was done on additional methods for trace constituents in high-purity water, including a

method for very low concentrations of chlorides. The growing industrial use of high-purity water for nuclear power plants, for use in processing electronics parts, and in other special applications points to a need for a whole new series of methods for traces of constituents and for properties.

Committee D-19 is now listing significant properties to be measured in "heavy water" and is developing methods for measuring these properties.

The rapidly increasing interest in measurement of radioactivity in industrial water, in determination of radionuclides, and in radioactive tracer techniques, prompted the committee to consider the establishment of a separate subcommittee to cover these areas.

Another likely field for a new subcommittee is the sampling and analysis of water-formed deposits. Work is being done first on improved sampling methods. Then will come qualitative, exploratory tests, and finally specific quantitative-analysis methods will be developed.

Final consideration was given to the scope and objectives of the committee-sponsored research on carryover in steam boilers. The primary objective will be to establish the extent to which whole compounds or specific ions are being carried over.

Coordination, Testing, and Analysis

E-1 on Methods of Testing At Work in Many Areas

Review of a new static compression test method for concrete cylinders, prepared by Committee C-9 on Concrete and Concrete Aggregates, has shown that it can be applied to other nonmetallic materials such as brick and stone. The title and scope of this method will accordingly be broadened and it will be established as an "E" method after approval by committee letter ballot.

Definitions of "secant modulus" and "tangent modulus" in Definitions of Terms E 6, will be revised. Also a number of definitions relating to fatigue testing, now published in *STP 91* and *91A*, will be added to Definitions E 6. The present definitions for elongation and reduction of area have been revised to apply to both metals and nonmetals.

Work is under way to develop two new methods for the determination of Young's modulus at elevated temperatures, one for temperatures up to 1000 F, and another above 1000 F.

A task group is studying possible changes in the method for verifying and classifying extensometers. Questions

are: (1) Is the magnification ratio of extensometers adequately described; (2) Does the definition of errors leave any reasonable basis for more than one interpretation of the method; and (3) How precise a measurement is necessary for determination of gage length of an extensometer at the time of calibration.

Methods for verifying testing machines at high strain rates are being considered. Strain rates under study are those specified for tension test of materials at elevated temperatures (E 21 and E 139), namely, either 0.005 or 0.05 per min up to the yield load; and either 0.05 or 0.10 per min from the yield load to fracture. Information was presented on the maximum load-rate and strain-rate capacities of four types of conventional testing machines. When testing standard 0.505-in. specimens, none of these machines meet the speed requirements of E 139, and two machines partially meet the requirements of E 21 for low-modulus materials (6×10^6 psi).

The scope of the Method of Determining Relative Humidity (D 337), originally prepared by Committee D-13 on Textile Materials, has been changed so that it can be more widely used in determining relative humidities. The revised method will be issued as an "E" method. The Standard Definitions with Procedures Relating to Conditioning and Weathering (E 41) are being revised and split into two separate standards, one covering definitions and the other the procedures. Specifications for Enclosures and Servicing Units for Tests Above and Below Room Temperature (D 1197), originally prepared by Committee D-20 on Plastics, are being revised to make them applicable to other materials. They will then be published as an "E" standard.

Extensive data on the rheological properties of elastomers at low temperatures will be submitted for publication in the *ASTM BULLETIN*. These data were compiled under the auspices of Subcommittee 27 on Low-Temperature Testing of Elastomers and Plastics. This subcommittee is now gathering laboratory data on the hardness of elastomers at low temperatures, which it also hopes to publish in the *ASTM BULLETIN*.

A conversion table for hardness and tensile strength of steel has been prepared jointly by the ASTM, Society of Automotive Engineers, American Society for Metals, and the Armed Services. This table will be in agreement with that appearing in Federal Standard QQ-M-151-A. This joint effort will result in the use of the same conversion table in the SAE Handbook, Federal Test Methods, ASM Handbook, and ASTM Standards for steel.

To the Rockwell hardness methods

(E 18) will be added a table showing the hardness ranges to be checked in calibrating with test blocks. Hardness conversion tables are being prepared for steel and aluminum alloys in the Rockwell B hardness range.

New Edition of Emission Spectroscopy Book in 1960

Preparations for a new edition of the book of *Methods for Emission Spectrochemical Analysis*, planned for publication late this year, constituted the major activity at the meetings of Committee E-2 on Emission Spectroscopy held on March 2 and 3 in Pittsburgh, Pa., in conjunction with the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy. Between 20 and 30 new suggested methods, published for information only, are expected to be ready for the new edition, in addition to those retained from the previous edition. Several tentative methods, some of which are based on the previous suggested methods, should also be ready for inclusion. Among new areas that are expected to be covered in the new edition are performance specifications for apparatus; suggested practices for flame photometry; and methods for analysis of titanium, zirconium, cerium, and indium. Work under way on other methods, including methods for the analysis of beryllium and gallium, is not expected to be completed for the 1960 edition of the book.

Additional projects nearing completion were the preparation of a bibliography on X-ray spectrographic literature and of a new edition of the Report on Standard Samples and Related Materials for Spectrochemical Analysis.

Panel Discusses Appearance Of Aluminum Surfaces

A high point of ASTM Committee Week was a Panel Discussion on Appearance of Aluminum Surfaces sponsored jointly by a task group of Committee E-12 on Appearance and Committee B-8 on Electrodeposited Metallic Coatings. A gathering of more than 150 heard the following three discussions:

Appearance Measurement from the Management Viewpoint—R. T. Myer, Kaiser Aluminum and Chemical Corp.

Gloss Measurements—Eric Barkman, Research Dept., Reynolds Metals Co.

Color Measurement of Transparent and Semitransparent Films on Aluminum—W. C. Cochran, Research Dept., Aluminum Company of America.

The speakers discussed the various problems resulting from the need for matching color and gloss of anodized high-silicon aluminum alloys. The excellent attendance as well as the oral discus-

(Continued on p. 79)

Tests for Potential and Past Moisture Expansion of Ceramic Building Units

By E. H. WATERS, J. S. HOSKING, and H. V. HUEBER

The tests originally proposed by Schurecht for the estimation of potential and past moisture expansion of whiteware and the modifications recently proposed by McBurney for application to burnt clay building units are critically examined.

The measured expansion of bricks standing in air and of replicates treated in the autoclave show that this latter test cannot be used to give a reliable estimate of the probable natural expansion of such bodies.

The determination of past expansion by reheating, while possibly more significant than the autoclave test, is also unsatisfactory because body composition, original firing temperature, and both the temperature and duration of reheating all affect the shrinkage produced. In some bodies expansion can be completely removed by heating to relatively low temperatures, but others require heating to temperatures approaching those at which the specimens were originally fired when the results are further confused by the occurrence of additional firing shrinkages.

ALTHOUGH it has long been known that burnt-clay products in contact with water or humid air slowly expand and that most of this expansion is not lost by drying at ordinary atmospheric temperatures (1-5),¹ it is only relatively recently that it has been recognized that this expansion of clay building units can cause serious structural damage (6, 7). McBurney (6) showed that moisture expansion could continue, at a rate sufficient to cause damage, for at least twelve years. Observations of buildings around Melbourne show that it can continue for much longer. In one large building, now 20 years old, the bricks are still expanding sufficiently to cause structural damage, and examples of failures of floor tiling in older buildings suggest that in some cases the expansion may continue for 50 yr or more.

When McBurney published his paper in 1954 he thought that the expansion of burnt-clay masonry units was relatively rare, but since then he has found it to be far more common in the United States than he originally thought (private communication.) Over the past few years many examples of damage to brickwork in Australia caused by such expansion have been brought to the attention of the present authors, and communications received from abroad indicate that it is by no means uncommon in England, Canada, and South Africa. In the laboratories of this

Division, hundreds of bricks have been examined, representing the various raw materials and brick-making processes in and around the cities of Melbourne, Sydney, and Adelaide, major centers of brick production in Australia, and although the results vary widely every



E. H. WATERS is in charge of the Division's investigations into wall and floor surfacing materials and has for some years been interested in the moisture expansion of ceramic bodies as a contributory factor in bond failures of tiling.

J. S. HOSKING is in charge of the Division's investigations into heavy clay ware for the building industry and, with H. V. Hueber, initiated the research into their moisture expansion in Australia. He is currently on loan to the Illinois State Geological Survey, Urbana, Ill., where he is investigating the comparable behavior of American clays.



H. V. HUEBER, a senior research officer in the team engaged in investigations into heavy clay ware, has been working on the moisture expansion of brick and other heavy clay products since he was the first to recognize the problem in Australia some years ago.



NOTE—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author or authors. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

¹The boldface numbers in parentheses refer to the list of references appended to this paper.

brick examined has been shown to be capable of permanent moisture expansion (7).

In addition to bricks, roofing tiles, wall and floor tiles, firebricks and other refractory products, chinaware and architectural terra cotta have also been studied and all show similar types of expansion. In all samples of building units examined, this capacity for expansion is sufficient to be potentially dangerous.

From our field and laboratory observations it seems likely that much cracking of clay masonry and lifting of wall and floor tiling, which in the past has been attributed to other causes, is in reality a result of the moisture expansion of the burnt-clay units. It is therefore important to have a means of estimating both the potential future expansion of a brick or tile and, in cases where damage has occurred, the expansion which has already taken place.

It is essential either that the results of such tests should be sufficiently reliable to give accurate estimates of past or probable future expansions or that the limitations of the tests be clearly understood. Otherwise, their usefulness in the design of clay masonry structures or in determining the cause of damage is doubtful.

Estimation of Potential Future Expansion

In a modification of the tests originally suggested by Schurecht (2) for a rather different purpose, McBurney has proposed that the potential future mois-

ture expansion of burnt clay units be taken as that produced by autoclaving the specimen for 3 hr at 295 psi (213 C), and further that a tentative limit of 0.05 per cent linear expansion from this treatment be placed on structural clay tile.

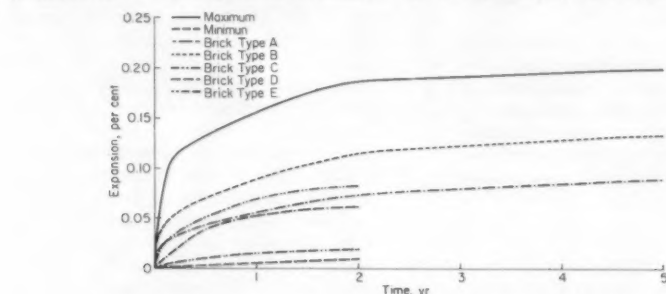


Fig. 1.—Mean moisture expansion curves for five types of brick from Melbourne and Sydney together with the over-all maximum and minimum expansion curves for all bricks examined on standing in an air-conditioned laboratory (21 C 50–65 per cent relative humidity).

ture expansion of burnt clay units be taken as that produced by autoclaving the specimen for 3 hr at 295 psi (213 C), and further that a tentative limit of 0.05 per cent linear expansion from this treatment be placed on structural clay tile.

The expansion of several hundred bricks has been studied, both standing in a normal atmosphere (approximately 250 bricks) and in saturated steam at 200 C (approximately 300 bricks). The results of these measurements are summarized in Figs. 1 and 2, where the brick types represented are: Type A, red stiff plastic bricks made from Silurian shales, mudstones and sandstones with some admixture of their weathered surface clays. Type B, cream stiff plastic bricks made from a mixture of Tertiary white clays with some of the weathered material used for making the former. Type C, wire-cut (stiff-mud) bricks made from either Silurian or Triassic shales, etc., mixed with their own surface weathered clay or clays of Tertiary or more recent age. Types D and E, semidry press facing and common bricks, respectively, made

from Triassic shales and their overlying weathered surface clays with more of the surface clays in the facing than in the common types; the bricks vary all the way from light burnt or porous to hard burnt or vitrified for each type examined. From these figures it is apparent that bricks vary widely in their potentiality for expansion and that a short period of autoclave treatment can produce expansions very much greater than those obtained after exposure to the atmosphere for five years. Most of the bricks examined had expanded by more than 0.05 per cent after exposure to the laboratory atmosphere for six

months, and after exposure for five years most had expanded by more than 0.1 per cent. Although the rate of expansion is now much less than in the first two years, it is still continuing and over the past two to two and a half years most of the curves have been very nearly linear, that is, the rate of expansion is diminishing only very slowly.

The universality of the expansion of burnt-clay products in contact with moisture and the large expansions observed make it clear that it will not generally be practicable to accept or reject burnt-clay building units according to their potentiality for expansion. All expand, and most to such an extent that allowance for this expansion must be made if structural damage is to be avoided (7).² What is required then is not so much an acceptance test but rather a means of providing the designer of the structure with data which he can use in making allowance for future expansion of bricks or tiles.

² Allowance can be made by: (1) using only well-burnt bricks, which in general expand less than underburnt ones, (2) storing the bricks for as long as possible before use (with many bricks the greater part of their expansion occurs in the first six months), (3) using mortars containing a high proportion of lime to portland cement, and (4) putting effective expansion joints in long walls at sufficiently frequent intervals to take up the residual expansion.

determined from the test data, together with test and field experience with some other type. However, experience has shown that the autoclave test fulfills neither of these criteria with sufficient accuracy to serve as a basis for design.

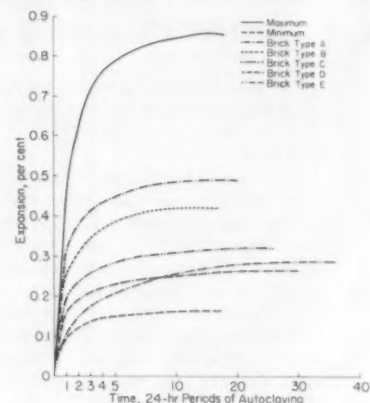


Fig. 2.—Mean moisture expansion curves for the same five types of brick shown in Fig. 1, together with the over-all maximum and minimum expansion curves for all bricks examined on drying at 100 C after autoclaving in saturated steam at 200 C.

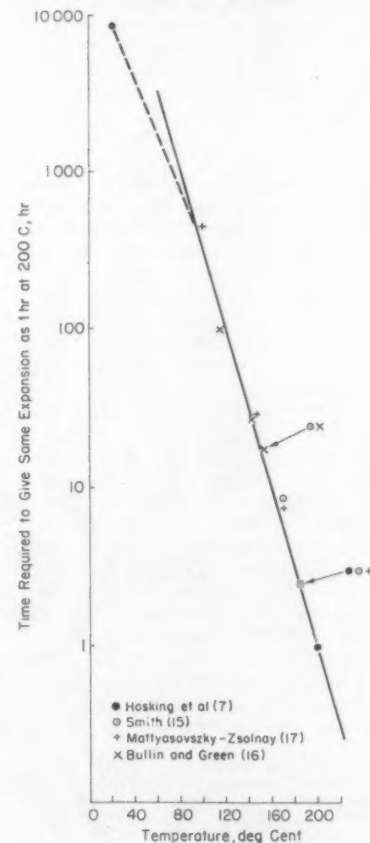


Fig. 3.—Effect of temperature on the rate of moisture expansion of clay bodies.

It has been shown elsewhere (7) that between 100 C and 200 C the rate of expansion by autoclaving changes fairly regularly by a factor of approximately 1.8 for every 10 C change in temperature, but at lower temperatures (21 to 100 C) this regular relationship breaks down (Fig. 3) and the expansion rate at atmospheric temperatures cannot easily be estimated from that found at temperatures above 100 C.

The low-temperature point in Fig. 3 was obtained by comparing the average time for bricks to expand linearly by 0.1 per cent both in the autoclave (200 C) and in the laboratory atmosphere (21 C). If this relationship of approximately $3\frac{1}{2}$ hr at 200 C equals 140

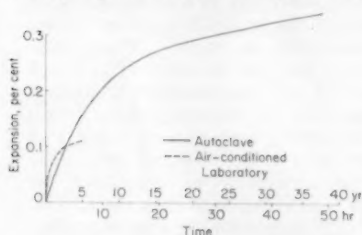


Fig. 4.—Average moisture expansion for all type A and B bricks of Figs. 1 and 2. (a) On standing in air at 21 C and 50 to 65 per cent relative humidity for 5 yr, and (b) on autoclaving at 200 C. (The time scales have been adjusted on the basis of 1 hr at 200 C equals 40 weeks at 21 C).

weeks at 21 C (1 hr equals 40 weeks) held throughout the expansion reaction, an estimate could still be made of the amount of autoclave treatment equivalent to the expected life of the building. However, closer examination of the data shows that at least for the bricks examined the relative rate of expansion at 21 C is greater than this in the early stages of the reaction but later is markedly reduced (see Fig. 4 where the two expansions have been compared on the basis of one hour at 200 C being equal to 40 weeks at 21 C). It is obvious that no possible adjustment of time scale can make the 21 C curve even approximate the 200 C curve. The reaction is not merely slowed down by a constant factor, its whole course is changed by the change in temperature. Until the specimens stored at 21 C have been studied for very much longer than 5 yr it will be impossible to be certain, but present indications are that it is unlikely that they will ever reach the expansions produced by autoclave treatment.

Since autoclave treatments of 100 to 600 hr were needed to bring bricks of various types to their ultimate expansions (7) even if the relationship of 1 hr equivalent to 40 weeks held throughout the expansion reaction, the bricks would require periods of from 75 to 450 yr to reach their final expansions. Because of the marked change in reac-

tion rate shown in Fig. 4, it is apparent that these expansions will not be reached for very much greater periods of time, if at all. It is therefore apparent that these ultimate autoclave expansions are quite unrealistic as a measure of future natural expansion.

The question then remains whether expansion after a limited period in the autoclave can be satisfactorily related to natural expansion. Holscher (8), Johnson and Plummer (9), Young and Brownell (10), Vaughan and Dinsdale (11) and Hosking, *et al.* (7), have all found poor correlation between autoclave and natural expansions (See also Fig. 5.)

Examination of the data from which

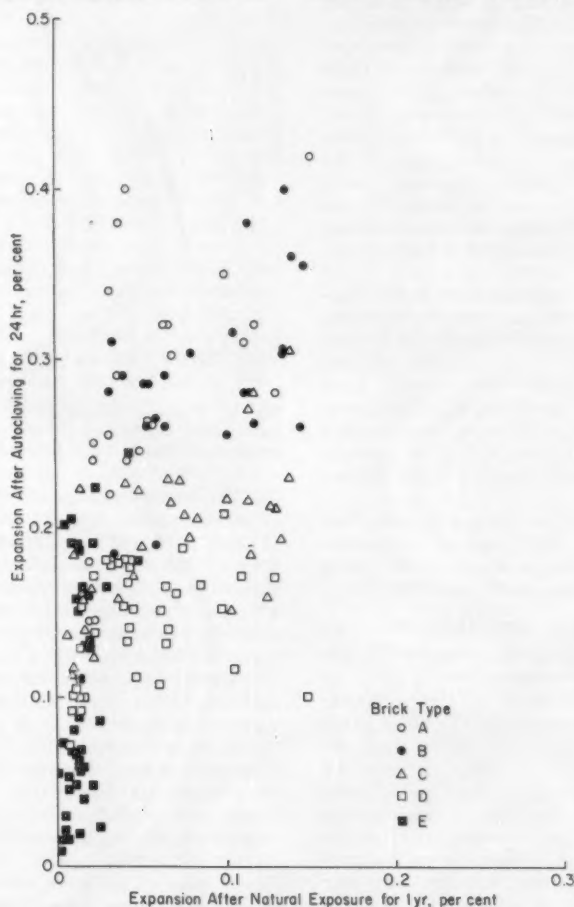


Fig. 5.—Comparison of moisture expansion of duplicate bricks standing in air for 1 yr and autoclaved at 200 C for 24 hr.

TABLE I.—RELATIONSHIP BETWEEN AUTOCLAVE AND NATURAL EXPANSIONS, IN PER CENT, OF TYPICAL BRICKS.

Expansion After Autoclaving 24 hr at 200 C	Expected Mean Expansion After Natural Exposure for 1 yr*	Limits Within Which the Natural Expansion of a Brick Having the Given Autoclave Expansion can be Expected to Fall with 95 per cent Certainty
150×10^{-3}	43×10^{-3}	0 to 120×10^{-3}
194.....	70	0 to 146
250.....	105	28 to 182

* Calculated from the regression equations.

Fig. 5 was constructed shows that if a sufficiently large number of specimens is considered, a general relationship between the two expansions can usually be demonstrated, but the precision is far too low to enable one to be satisfactorily predicted from the other. For four out of the five brick types examined there was a statistically highly significant correlation coefficient of between 0.5 and 0.6; for the fifth the correlation coefficient was lower (0.3) and significant only at the 10 per cent level. However, when regression equations and confidence limits were calculated it became apparent that despite the significant correlation the calculation of one expansion from the other with any reasonable

TABLE II.—PER CENT MOISTURE EXPANSION OF BULLIN AND GREEN'S SAMPLES (16).

After Autoclaving	After 24 hr at 160 C	After 48 hr at 160 C	After Refiring to B.R. 4, 1008 C	After Refiring to B.R. 15, 1065 C
0.143.....	0.109	0.092	0.009	..
0.156.....	..	..	..	..
0.146.....	..	..	..	-0.013

precision was not possible. An example of the type of relationship found is given in Table I.

This unsatisfactory relationship is apparently due to the autoclave expansion being not simply an acceleration of the natural expansion but, in part at least, an expansion produced by reactions other than those that occur at ordinary temperatures. This is shown both by the difference in the temperature coefficient of expansion above and below 100 C and by Vaughan and Dinsdale's finding (11) that a given weight of water absorbed at room temperature produces a change in size different from that produced by absorption of the same weight of water in steam treatment. Young and Brownell (10) also show that reactions during autoclaving differ from those under ambient conditions.

That is, although autoclave treatment produces accelerated expansion, this probably happens, at least to some extent, by substituting other reactions and not only by accelerating the reactions occurring at lower temperatures. It is therefore not unreasonable that there is no precise correlation between the expansions produced under the two conditions.

The autoclave test consequently does not form a sound basis for a quantitative estimate of the probable future expansion of burnt-clay building units.

Estimation of Past Expansion

McBurney (6) has proposed that the contraction produced in a body by heating it to 400 C and then cooling to room temperature shall be taken as the moisture expansion which had occurred prior to the test. However, the results of earlier workers and of more recent investigations in this Division (12) show that the moisture expansion obtained by McBurney's method may be much too low, in many cases even to the extent of being less than half the true value. In other cases the method may give reasonably correct values.

The earliest recorded indication of the existence of moisture expansion was given by the change in the apparent coefficient of thermal expansion produced when ceramic bodies which had crazed from exposure were heated (1). When Schurecht (2) investigated the relationship between moisture expansion and delayed crazing he used this method to establish that the crazed ware had expanded. It appears from his

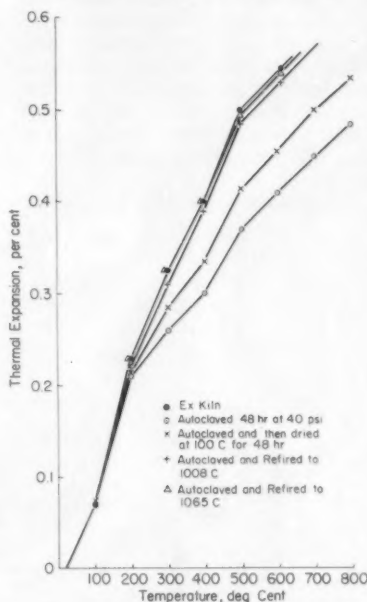


Fig. 6.—Thermal expansion of wall tile bodies after various treatments (from the results of Bullin and Green (16)).

thermal expansion curves that the moisture expansion begins to disappear at about 120 C and has completely gone by about 350 C. However, in his direct measurements on experimental bars which had been expanded in the autoclave, he was unable to remove all the expansion even by heating to 450 C. The actual recovery obtained in the four different bodies used in these tests varied from 64 per cent to 82 per cent. On the basis of these results, Schurecht then recommended heating to 600 C as a means of determining approximately how much a ceramic body has expanded by absorption of water.

Since Schurecht's paper was published, most of the work on moisture expansion has been done by measuring the actual expansions of experimental specimens of which the ex-kiln dimensions are accurately known, and very little attention has been given to the problem of determining the expansion of bodies of unknown ex-kiln dimensions. What little information is available suggests that the impression gained from Schurecht's curves and which apparently influenced his recommendation and McBurney's subsequent modification is an oversimplification. The extent to which any given heat treat-

ment will return a body to its original dimensions appears to depend not only on the temperature to which it is heated but also on the duration of this heating, on the composition of the body, and on the temperature at which it was originally fired. Holscher (8) showed that drying at 110 C for 40 days would remove 64 per cent of the expansion produced in his experimental bars by 6-hr steaming at 150 psi (as much as one of Schurecht's specimens lost at 450 C). Further treatment at this temperature produced negligible recovery. Geller and Creamer (13) found "that autoclaved specimens of earthenware which have expanded due to reaction with moisture apparently return to their original length when held for a reasonably short time at 250 to 270 C in air and under atmospheric pressure." They autoclaved their specimens for 1½ hr at 150 psi but give no indication of what is meant by "a reasonably short time." The present authors have found that specimens of architectural terra cotta expanded by autoclaving at 200 C for 240 hr lost from 33 to 40 per cent (average 36 per cent) of this expansion when they were held for 24 hr at 240 C. Thiemcke (14), on the other hand, found that temperatures greatly in excess of Schurecht's 600 C were needed to remove the autoclave expansion (3 hr at 100 psi) from some of his experimental specimens. Two clays fired without admixture returned to their ex-kiln size after 24 hr at 150 C. The remainder of his natural clays and some mixed bodies lost all their expansion after heating to 700 C, but the majority of the mixed bodies needed to be heated to cone 08 (approximately 950 C) to do this, and some semivitreous bodies containing a high percentage of flint did not do so even then; some of the latter retained almost half of their original expansion. Smith (15) also found that one of the bodies which he autoclaved did not return to its original size even when heated to 1000 C.

It is difficult to correlate these results because the compositions of the bodies used by the various investigators are different, and for most of the experiments no clear indications have been given of the times for which the specimens were heated.

A further investigation of the effect of temperature and time on the removal of moisture expansion was made by Bullin and Green (16), but only one batch of wall tiles and three temperatures were used, and for the higher temperatures the times of treatment were not given. They took a batch of tiles after biscuit firing to Buller's Ring 30 (1170 C) autoclaved them (48 hr at 40 psi) and then heated portions of the batch at three different temperatures (see Table II). Thermal

expansion measurements were made at each stage from which, by the change with temperature of the coefficient of thermal expansion, the presence of moisture expansion can be seen. (This is the method by which Schurecht (2) originally demonstrated the existence of moisture expansion.) The results of these thermal expansion measurements have been plotted in Fig. 6.

Both Table II and Fig. 6 show the gradual shrinkage of the specimens as they are heated for longer periods or at higher temperatures. An interesting feature of these results is that although from the thermal expansion curves the pieces refired at 1065 C appear to have some moisture expansion remaining, the measurement of the actual dimensions of the test pieces shows a net shrinkage.

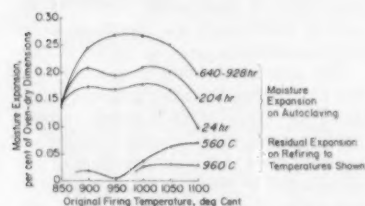


Fig. 7.—Effect of refiring to different temperatures on the removal of moisture expansion from roof tiles fired originally over a range of temperatures from 850 to 1100 C. (After Cole (12))

In a study of the relationship between moisture expansion and the deterioration of roofing tiles, Cole (12) has obtained similar results on the recovery of moisture expansion by heating. He found in addition that the temperature at which the specimen was originally fired had a marked effect on the extent to which the moisture expansion was removed by any subsequent heat treatment (see Fig. 7).

The position appears to be that while some bodies will lose their moisture expansion at relatively low temperatures (even below 300 C), others require very much higher temperatures to do so, some retaining almost half their expansion after heating to 950 C. On the other hand, heating to temperatures approaching the original firing temperature may produce a contraction greater than the original expansion. It therefore does not appear possible in our present state of knowledge to nominate a heat treatment schedule which can be guaranteed to return a moisture-expanded body to its ex-kiln dimensions. An extensive series of experiments on a wide range of bodies expanded both naturally and in the autoclave, and whose ex-kiln dimensions are known, will be necessary and such an experimental program is to be started shortly.

Conclusions

The universality of the expansion of burnt-clay products once they leave the kiln and the magnitude of the expansions commonly observed in bricks and similar burnt-clay building units makes the use of an acceptance test based on their potentiality for expansion impracticable. Allowance for this expansion must be made in the design of the structure and the way in which the bricks are used.

The autoclave test is not a satisfactory means of determining what allowance should be made. Although it produces an accelerated expansion which is related in a general way to that which occurs when the units are simply left to stand in a normal atmosphere, the correlation between the two is not good enough to enable one to be satisfactorily estimated from the other. A probable reason for this is that the reactions causing expansion in the autoclave are not solely those causing expansion at room temperature. Design data on expansion can hence only be obtained by long-term studies on similar bricks or tiles.

Although an approximate idea of the amount by which an aged specimen has expanded can usually be obtained by reheating it, the effects of body composition and original firing temperature on the recovery of expansion in this way are such that in some cases it has proved impossible to remove expansion without heating to temperatures approaching those at which the specimens were originally fired. At these temperatures, further firing shrinkages occur and the two effects become confused; this suggests that even at lower temperatures the shrinkage obtained by heating is not necessarily wholly caused by a reversal of the expansion process, and hence any approximate numerical agreement may be quite fortuitous.

Acknowledgment

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Measurement of Environmental Stress-Cracking of Polyethylene

By A. RUDIN and A. M. BIRKS

WHEN polyethylene is stressed biaxially or polyaxially in the presence of surface-active environments such as soaps, alcohols, and wetting agents the polymer often cracks, although the stresses are such that the resin could endure them indefinitely in the absence of the polar environment. This phenomenon is termed "environmental stress cracking." The cracks are generally sharp, conchoidal fractures. Environmental stress cracks often occur after a relatively short exposure to the cracking medium and with severe consequences, since the breaks usually extend completely through the article.

Environmental cracking, first reported in 1946 for high melt index polyethylene (1),¹ became very important in 1948 when the polyethylene sheath on a multicore telephone cable cracked under polyaxial stressing in the presence of duct lubricants (2). Since recognition of the cause of this particular failure, there have been many recorded instances of environmental stress cracking of polyethylene articles.

The occurrence of the telephone cable failure led Bell Telephone Laboratories to devise a laboratory test method to evaluate this property of polyethylene (2). This test is performed on specimens cut from compression-molded sheet. One face of each oblong specimen is nicked with a razor blade to produce a region of stress concentration. The notched specimen is bent through about 135 deg held in that position, and exposed to a cracking environment. The exposure time before the specimen cracks is observed. This test method reproduces the type of failure observed in the cracking of the telephone cable sheath and has been used as part of the Bell organization purchasing specification to guard against a repetition of that event.

Subcommittee XV on Thermoplastic

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¹The boldface numbers in parentheses refer to the list of references appended to this paper.

²ASTM Standards on Plastics, Am. Soc. Testing Mats., Sept., 1958, p. 1049.

³A copy of the revised test method may be obtained from the authors.

Materials of ASTM Committee D-20 on Plastics established a task group in 1954 to investigate this test method. Some progress toward a useful test was made but three large interlaboratory trials demonstrated considerable variance of test results. Within one laboratory, successive tests were reported to give generally fair agreement. The correlation between laboratories was so poor, however, that the task group concluded that different testers could not be expected to agree on fifty per cent failure times. For this reason, the test was written to apply on a "go—no-go" basis and has been published as tentative method D 1693-59 T.²

The precision of this method on our own laboratory was not actually so good as the ASTM task group report implied. Analysis of our values obtained over a period of two years showed that, with the normal ASTM version of this test procedure, but using 40 test specimens, one may expect with 95 per cent probability that

$$0.65 F < f < 1.55 F$$

where:

f = 50 per cent cracking time estimated for 40 specimens, and

F = true 50 per cent cracking time.

Increasing the number of specimens does not improve the precision to an extent that would justify the additional effort.

Interest in this test remains very great in the plastics industry, however, despite its poor precision. The incidence

of stress-crack failures is not low, particularly in pipe and to some extent in injection moldings, which are not usually protected by strict raw material specifications such as those that now apply to telephone cable jacket resin. The situation is aggravated by the general lack of understanding of the causes and prevention of this phenomenon on the part of fabricators and users of polyethylene articles.

The aim of the work reported here was to improve the interlaboratory precision of the environmental stress-cracking method. Another objective was to extend our understanding of the significance of the test results so as to carry out the test method most efficiently, make the best use of the results, and avoid applying the test data where they could be inappropriate.

Environmental Stress-Cracking Test Method

The test method³ used in our laboratories now is a refinement of the Bell Telephone Laboratories' method, as described by the ASTM.² Changes were made in the definition of an environmental stress crack failure and in specimen preparation, specimen cutting, treatment of test data, test temperature, and cracking agent. None of the modifications which have been made changes the fundamental nature of the original test method, but the interlaboratory precision and convenience of operation have been very considerably



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improved compared to the ASTM version.

Round-robin trials within our company have shown that the 95 per cent confidence limits of a single result from one laboratory is about ± 30 per cent. That is, a laboratory can expect that other groups will reproduce its own 50 per cent failure time to within 30 per cent of that value.

Various aspects of the test method are discussed below, with emphasis on their effects on the precision of test results and the ability of the method to discriminate between different polyethylenes. The separate details of the test are considered in the sequence in which they first appear in the ASTM

method and the reason for departing from the original version and the results of these changes are summarized. The significance and interpretation of test results are considered in subsequent sections of this paper.

Definition of Stress-Crack Failure

A major cause of the poor interlaboratory precision of the ASTM method is the operator-to-operator difference in deciding whether or not a specimen has cracked. This error can be minimized by defining a failure very clearly, keeping a tentative score of failures against time, and choosing test conditions which avoid long exposure times before failures occur.

The definition of stress-crack failure given in the preamble to the ASTM test is accurate as far as it goes, but it is not specific enough. The entire test is based on the determination of the time at which test specimens fail, so that ambiguity in the definition of a failure will result in a corresponding increase in between-operator error of test results. This is illustrated by the results in Table I of a round-robin trial of the environmental stress-cracking method, involving three laboratories within our company. A statistical analysis of these figures revealed the large errors which could result from disagreement as to when a specimen should be counted as having failed.

An obvious remedy for this defect of the test method is to specify exactly what should be considered an environmental stress-crack failure and what should not. This alone cannot, however, completely eliminate operator judgment. Failures sometimes manifest themselves first as dimples or flow marks in the specimen surface, rather than as full-fledged splits. These flaws may persist for quite some time before an actual crack appears. An experienced observer will recognize such a flow mark as an incipient failure, but the failure time is still a matter of judgment. The importance of this source of error can be reduced by keeping a tentative score. Surface flaws are recorded as possible failures when they are first observed and the running score of number of failures against time is corrected by subsequent observations as to whether or not the suspected failure has developed into a clearly visible crack. If a split visible to the naked eye does not develop during the period of the test, the suspected failure is not counted. This approach, which appears to be a logical and necessary feature of a test of this type, is illustrated by the data in Table II.

Since it is clearly impossible to define a stress-crack failure precisely enough to eliminate operator error completely, an attempt should be made to choose test conditions which provide the least room for disagreement along these lines. It is useful in this connection to avoid long

TABLE I.—FIRST CIL^a INTERLABORATORY MEASUREMENT OF ENVIRONMENTAL STRESS-CRACK RESISTANCE.

Values listed are those for each test tube (10 specimens). See Proposed Method for Stress-Cracking of Plastics, ASTM Standards on Plastics, Sept., 1958.

Specimen Preparation	50 per cent Failure Times, F_{50}		
	Laboratory A	Laboratory B	Laboratory C
Specimen: RR-1, melt index 2, type I (ASTM D 1248); cracking agent, Lissapol N (ICD); annealing, 1 hr in boiling water; test temperature, 40 C. Failure time in minutes.			
Molded, cut, annealed and notched at laboratory A.	30.5	23.5	32
Molded at laboratory A, cut, annealed, and notched at each location.	9	22.5	36
	14	20.5	38
	30	40.5	40
	33	39.5	46
Entire preparation at each location.	35	31.5	44
	30	35.5	38
	37	29.5	45
	36	33.5	48
Specimen: RR-2, melt index 7, type I (ASTM D 1248); cracking agent, turpentine; test temperature, 40 C. Failure time in hours.			
Molded, cut, annealed, and notched at laboratory A.	6.0	4.9	5.3
Molded at laboratory A, cut, annealed, and notched at each location.	5.0	6.3	3.8
	6.0	4.9	2.0
	5.9	9.5	4.7
	6.0	10.4	4.2
Entire preparation at each location.	7.8	9.5	4.3
	5.5	9.3	6.3
	5.0	10.0	5.8
	4.6	9.8	4.8
Specimen: RR-3, melt index 0.4, type I (ASTM D 1248); cracking agent, 20 per cent aqueous Hostapal HL (Hoechst); test temperature, 40 C. Failure time in hours.			
Molded, cut, annealed, and notched at laboratory A.	23	...	210
Molded at laboratory A, cut, annealed, and notched at each location.	41	...	190
	18	...	58
	20	...	215
	17.5	...	240
Entire preparation at each location.	14	...	240
	32.5	...	240
	26	...	240
	26	...	230

^a Canadian Industries Ltd.

TABLE II.—ENVIRONMENTAL STRESS-CRACKING DATA.

Specimen: X-10, melt index 0.2, type I (ASTM D 1248); cracking agent: 20 per cent Hostapal HL; annealing: cooled from melt at 5 C per hr; test temperature: 50 C.

	Trial	Zero Time, a.m.	Number Failures in 10 Specimens at Various Exposure Times																
			5 min	10 min	15 min	30 min	45 min	1 hr	1.25 hr	1.5 hr	2.0 hr	2.5 hr	3.25 hr	4.25 hr	5.0 hr	5.5 hr	6.0 hr	7.0 hr	8.0 hr
Tentative score	1	9.09	0	0	0	0	0	0	0	0	1+1?	3	5	5	6	7	7	8	8
	2	9.12	0	0	0	0	0	0	1	2?	2?	2	2	3?	3	5	7?	6	9
	3	9.15	0	0	1?	0	0	0	1	1	2	3?	3?	2	2	4?	5	6?	8
Corrected score	1		0	0	0	0	0	0	0	2	3	5	5	6	7	7	8	8	8
	2		0	0	0	0	0	1	2	2	2	2	3	3	5	6	6	9	9
	3		0	0	0	0	0	1	1	2	2	2	2	2	4	5	6	6	8
Total per cent failures			0	0	0	0	0	6.7	10	13.3	20	23.3	30	33.3	36.7	53.3	60	66.7	83.3

TABLE III.—PRECISION OF ASTM ENVIRONMENTAL STRESS-CRACKING TEST.^a

Laboratory	50 per cent Failure, hr		
	Trial 1 ^c	Trial 2 ^c	Average
SAMPLES PREPARED AT CENTRAL LABORATORY ^b			
B.....	8.2	6.5	7.3
C.....	2.0	24.0	13.0
D.....	8.3	6.0	7.2
E.....	10.0	16.0	13.0
F.....	13.0	24.0	18.5
Over-all average: 10.4 hr			
SAMPLES PREPARED AT INDIVIDUAL LABORATORIES ^b			
G.....	100	200	150
H.....	>336	>336	>336
I.....	12.0	4.9	8.0
J.....	24.0	27.0	26.0
K.....	5.8	2.3	4.0
L.....	10.0	10.0	10.0
Over-all average: >89 hr			

^a See ASTM Standards on Plastics, Sept. 1958, p. 1048.

^b Data from second ASTM round robin. Same polyethylene in both sections of this table.

^c Each trial consisted of 10 specimens.

exposure times before failures occur and to use well-annealed specimens. The "surface flaw" type of failure mentioned in the preceding paragraph is particularly evident in crack-resistant polyethylene, where the test extends over relatively long exposure times. The choice of test conditions such that the specimen fails completely within one or two days causes a marked decrease in the incidence of this difficulty. This is probably one of the most effective methods for eliminating the between-operator error described in this section. Operator error is much reduced when well-annealed specimens are tested; it bulks larger with quenched specimens. This point is discussed below under "Precision of Revised Test Method."

Preparation and Conditioning of Test Specimens

Molding variations—a major source of interlaboratory error in this test—can be controlled through the use of post-molding conditioning procedures (3).

The result of ASTM trials of the stress-cracking test method indicated that molding variations are a major cause of discrepancies among data from different laboratories. The magnitude of this error is illustrated by the ASTM values in Table III, where the variation of test results is seen to be much less for test specimens prepared at a single location than for specimens prepared at each testing laboratory. Table IV lists our own data which illustrate the pronounced effects of thermal history of specimens on this stress-crack resistance. Other examples have appeared in the recent literature (4) and the point has been stressed in a review article (5).

TABLE IV.—EFFECT OF THERMAL HISTORY OF POLYETHYLENE ON ITS ENVIRONMENTAL STRESS-CRACK RESISTANCE.

Thermal History	50 per cent Failure Time, hr	
	Sample 40	Sample 60
Test temperature, 50 C; cracking agent, 20 per cent aqueous Hostopal HL (Hoechst); specimens: melt index for both 0.3, type I (ASTM D 1248).		
1 hr annealing in boiling water.	<8	No failures in 9 days
Cooled from melt at 8 C per hr	1.25	5.5
Test temperature, 30 C; cracking agent, 20 per cent aqueous Igepal CO 630; specimen: melt index 2, type I (ASTM D 1248).		
Cooled in press from 150 C to 75 C in 7 min.		11.5
Cooled in press from 150 C to 80 C in 30 min.		3.3

Two postmolding specimen conditioning methods have been described (3) for use in conjunction with stress-cracking and other mechanical tests on polyethylene. Both procedures, which differ only in the rate at which the material is cooled from the melt, are reproducible and both apparently eliminate the effects of wide variations in specimen-molding conditions. The reader should refer to the cited article (3) for details of these conditioning methods. So far as we know, the above-mentioned difficulties due to molding variations can be completely eliminated by the use of the recommended preparation procedures.

Experience at our own and other laboratories (6) has shown the necessity of compression-molding sample sheets from milled polyethylene crepe. Anomalous test results are sometimes obtained when the sample sheets are molded directly from granules, as permitted in the present test procedure.

Specimen Cutting and Bending

Variation of the stresses applied to the specimens during bending and exposure to the cracking agent are important sources of poor precision of test results. This can be minimized by using a bending clamp and transfer tool² to bend the specimens and place them in their holders. It is essential, in this connection, that the specimens be cut with square edges and that the holders have the specified dimensions. In this case, no departure from the ASTM test method is involved; it is emphasized rather that the directions for cutting and handling test specimens must be strictly followed.

Statistical Treatment of Test Data

The usual method for handling test data does not supply any information about the distribution of failure times

from which the reported median value is extracted. Some unsuccessful attempts to correct this situation are recorded in the following section, and it is pointed out that statistical treatment of stress-cracking data is made easier by the use of specimens conditioned by cooling at a slow rate from the melt and choice of test conditions such that the experiment is completed within one or two days.

The common method of handling test results consists of plotting per cent failures against time and joining the experimental points with a best-fit straight line. The plotted values actually often fall in an S-shaped pattern, especially when the exposure time is long. The time for 50 per cent failures, read from the best-fit straight line, corresponds to the median survival time. It is used to characterize the material, but it does not give the whole story since no information is supplied about the distribution of failures from which the median was drawn. The median of a narrow distribution would be more useful for characterizing the material than the median of a very broad distribution. Further, two samples with identical median survival times might have very different exposure times for initial or complete failure. The test method would be better if its results included not only an average figure for the measured property but also an indication of the scatter of the test data. These requirements are usually met in rupture tests by reporting an average treatment for failure and a standard deviation. The standard deviation of the distribution of failures is appropriate to a test like stress-cracking where extent of failure is measured against severity of treatment. It is also a convenient figure to use, since a good approximation can be obtained very simply from the slope of the straight-line plot of per cent failures against exposure time (3).

This usage presupposes a straight-line relationship between severity of treatment and some function of the mortality rate of test specimens. An effort was made to find a transformation for the proportion of failures such that the transformed function would bear a straight-line relationship to the exposure time in this test. This approach met with very limited success and was finally abandoned when it became apparent that the results of the ASTM version of the test did not always fit into any single distribution. The observed distributions of failures were so varied and unpredictable that a single transformation could not be of much general use.

The problem has been reduced in severity, if not entirely solved, by the use of conditioned test specimens (3) and the proper adjustment of test condi-

tions (see following section) resulting in distributions of failures that are more uniform and amenable to statistical treatment. Both the annealing of test specimens and the choice of test temperature and cracking agents are dictated by other considerations, which are discussed in the appropriate sections of this article. It is a very gratifying coincidence that these modifications of the test have resulted in characteristically sharp distributions of failures and linear plots (on probability paper) of proportion of failures against exposure times. The

TABLE V.—BETWEEN-OPERATOR PRECISION OF REVISED TEST METHOD.

Sample ^a	Melt Index	Conditioning ^b	Test Conditions	50 per cent Failure Time	
				Operator A	Operator B
A 61.....	20	Fast-cooled	c	54 min	52 min
A 21.....	8	Fast-cooled	c	11 min	9 min
A 55.....	0.4	Slow-cooled	c	378 min	387 min
A 20.....	2	Fast-cooled	d	7 min	6 min
A 20.....	2	Slow-cooled	d	7 days	7 days

^a All specimens type I (ASTM D 1248).

^b Conditioning procedures are described in a related article (9). Molded specimens were remelted and plunged directly into cold water for fast-cooled conditioning, or cooled to room temperature at 5 C per hr, for slow-cooled conditioning.

^c 20 per cent aqueous Hostapal HL, 50 C.

^d Igepal CO 630, 50 C.

^e 0.25 per cent (W/V) Ivory Snow-0.2 per cent (V/V) tributyl phosphate, 30 C.

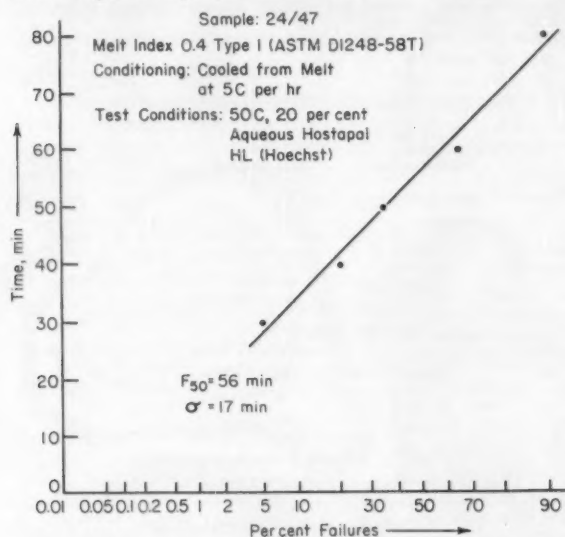


Fig. 1.—Linearity of per cent failures time plot.

linearity of this plot is an advantage in several respects. In the first place, since a straight line can be used to approximate the experimental points, all the data can be used to determine the position of this line and the value of the median failure time which is estimated from it. Secondly, a measure of it can be made of the time between initial and complete failure.

The most convenient estimate of the latter parameter in this case is σ , the standard deviation of distribution of failures. It is estimated here as equal to the time interval corresponding to a change of 34 per cent in the proportion of failure (3).

A report including the median failure time, F_{50} , and the standard deviation, σ , enables one to reconstruct the test results to a reasonable approximation. It also indicates whether two specimens with equal 50 per cent failure times are really equivalent. The standard deviation of distribution of failures, σ , is always less than 20 per cent of F_{50} in properly conducted tests. Typical test results are shown in Fig. 1.

Test Temperature and Cracking Agent

The test temperature, cracking agent, and cooling rate during postmolding

conditioning should be so chosen that the observation time comprises at least 30 min and is less than about 8 hr. Shorter experiments save testing time, while the requirement that the minimum exposure time should be 30 min insures that the specimens will not be broken so rapidly that discrimination between samples will be lost.

The ASTM version of this test method requires the use of one reagent, Igepal CO 630, at a specified temperature of 50 C. It is, however, not practical to apply this (or any) one test condition to all commercial polymers. Very soft materials cannot be distinguished because of their very short survival times, while discrimination between low melt index polyethylenes is lost when they do not break at all. An example of the effect of test temperature, in Fig. 2, shows that the sensitivity of the method can be lost if the test conditions are not adjusted for discrimination between the particular samples which are to be examined.

The term "test conditions" here means temperature and cracking agent although specimen conditioning, which was discussed above in the section on preparation and conditioning, is also an important factor. The choice of a

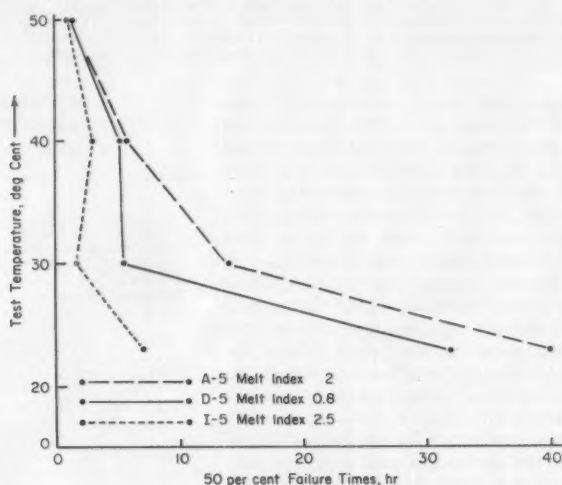


Fig. 2.—Effect of test temperature.

Cracking agent: 20 per cent aqueous Igepal CO 630; All specimens were type I, ASTM Specification D 1248.

particular test condition is governed mainly by the requirement that it discriminate between the samples being tested, but it should also be convenient to operate. The latter requirement will usually mean conditions such that the stress-cracking test is completed within one, or at the most, two days. This results not only in an economy of testing time but also in improved precision over the results of more prolonged stress-cracking tests.

Ideally, a stress-cracking test should require at least about $\frac{1}{2}$ hr and less than 8 hr exposure time. Under these circumstances specimens will not be broken so rapidly that different polyethylenes cannot be distinguished, nor will the test last so long that stress relaxation becomes a major factor. We have found, in practice, that it is not difficult to select cracking conditions which will allow completion of the test within 1 to 8 hr.

Variability of Cracking Agents

Nearly all the widely used cracking agents are commercial soaps and detergents. As such, any quality control exercised in their production is for uniformity of detergent action and not for their effects on polyethylene. Some cracking agents are probably not very

TABLE VI.—SECOND ENVIRONMENTAL STRESS-CRACKING ROUND ROBIN.

All samples were type I, ASTM D 1248.

Sample ^a	Condition ^a	Cracking Agent	Test Temperature, deg Cent	Median Failure Time (F_{50} min) and Standard Deviation of Distribution of Failures (σ min) ^b					
				Laboratory A		Laboratory B		Laboratory C	
				F_{50}	Standard Deviation	F_{50}	Standard Deviation	F_{50}	Standard Deviation
I.....	Slow-cooled	Igepal CO 630	40	7	1	7.5	1	9	1.5
II.....	Slow-cooled	20 per cent Hostapal HL	40	38.5	6	29.5	6	36	6
III.....	Slow-cooled	20 per cent Hostapal HL	50	81.5	1	128	28	90	14
IV.....	Slow-cooled	20 per cent Hostapal HL	50	18.5	1	19	4	22	5
V.....	Slow-cooled	0.5 per cent Igepal CO 630	35	100	11	118	25	135	6
VI.....	Fast-cooled	Igepal CO 630	40	30	2	12.5	8	16.5	2
VII.....	Fast-cooled	0.25 per cent Ivory Snow	30	50-60	...	139	15	94	11

^a Conditioning procedures are described in a related article (3). Molded specimens were remelted and plunged directly into cold water, for fast-cooled conditioning, or cooled to room temperature at 5 C per hr, for slow-cooled conditioning.

^b Standard deviation of distribution of failures, σ , is an indication of the time interval over which failures occurred. In this case it equals $F_{84} - F_{50} = F_{50} - F_{16}$ where F_{84} is the time to 84 per cent failures.

stable when stored; Igepal, used in the ASTM test, is hygroscopic and its water content influences the severity of its action on polyethylene. Variability of cracking agents is undoubtedly a source of interlaboratory error and of discrepancies between results of tests at different times in one laboratory.

Ideally, the cracking agents should be formulated from chemicals that can be ordered by specification and not by trade name, as at present. Since the requirements for a cracking agent are not only that it be uniform but that it crack given samples within a specified time, the search for such formulations was best postponed until other aspects of the test method, which would probably interact with the cracking agent, were under control. These factors now seem to be under control and a search should be started for more readily standardized cracking agents. A testing group, like the ASTM, should probably undertake this work.

Precision of CIL Test Method

It was observed quite early in this work that the within-laboratory precision of the environmental stress-cracking test was considerably improved by following the modified test method described above. This is illustrated by a trial where two operators each performed the complete stress-cracking test, from milling and pressing the granule samples to observation of the failure times of the test specimens. The results are given in Table V.

A round-robin trial between three laboratories gave the data listed in Table VI. The slow-cooled test results (first five entries in Table VI) were analyzed statistically with the following conclusions:

1. There were no significant between-laboratory differences at the 95 per cent level of confidence.

2. 95 per cent confidence limits on any single observation, by any laboratory, are close to 30 per cent above and 23 per cent below the quoted figure. In other words, a laboratory could expect, with 95 per cent confidence, that

TABLE VII.—EFFECTS OF VARYING TEST CONDITIONS.^a

Cracking Agent	Time for 50 per cent Failure, hr		Ratio of Cracking Times
	Sample B24	Sample D66	
Changing Cracking Agent ^b			
Saturated flax soap solution.....	138	110	1.25
Igepal CO 630, 100 per cent.....	>312	>312	1.0
Igepal CO 630, 20 per cent aqueous.....	>312	17	>18
Lissapol N (I.C.I.).....	>312	60	>5
Hostapal HL (Hoechst).....	72	20	3.6
Changing Test Temperature ^c			
Test Temperature, deg Cent	Sample A5-27	Sample I5-35	Ratio of Cracking Times
50.....	1.25	1.15	1.1
40.....	5.8	3	1.9
30.....	14	1.7	8.2
23.....	40	7	5.7
Changing Specimen Annealing ^d			
Annealing	Sample N	Sample D	Ratio of Cracking Times
Annealed 1 hr in boiling water.....	<8	No failures in 9 days	>27
Cooled from melt to room temperature at 8 C per hr.....	1.25	5.5	4.4

^a Specimens were Type I (ASTM Specification D 1248).

^b Test Temperature 50 C; conditioning: specimens annealed for 1 hr in boiling water.

^c Cracking agent: 20 per cent aqueous Igepal CO 630; conditioning: specimens annealed for 1 hr in boiling water.

^d Test temperature 50 C; cracking agent: 20 per cent aqueous Hostapal HL.

test data measured elsewhere will not deviate by more than 30 per cent from its own figure for a particular sample.

The between-laboratory reproducibility of the test is considerably better than the within-laboratory precision of the original method, as described in the introduction to this article. The method appears to be suitable, as it now stands, for interlaboratory and specification testing.

Stress-cracking tests on slow-cooled specimens are more precise than on fast-cooled specimens because cracks propagate faster under the former condition. There is not usually much room for disagreement on failure times because only a relatively short time elapses, with slow-cooled specimens, between the appearance of a surface flaw and its development into an obvious split. This is not the case for fast-cooled specimens, where fine cracks persist for longer times before opening.

It is preferable, in general, to use

slow-cooled specimens whenever possible in standard tests whose results are to be compared between laboratories.

Significance of Test Results

In this test, the choices of temperature, cracking agent and conditioning method have drastic effects on the observed survival times. Variation of any of these factors causes the cracking times of different resins to change to different, unpredictable extents. If a number of polyethylenes are ranked in a certain order in a test using a specified conditioning procedure, cracking agent and temperature, the order of merit will usually (but not invariably) be unchanged when these test variables are changed. The ratios of crack times of different resins will, however, almost certainly be altered. Some examples are given in Table VII.

The test results quoted in Table VII are all equally valid. There is no reason to prefer one test condition over another

except when that condition is similar to an environment likely to be encountered by articles in use. (For example, a test condition employing wire drawing compounds as cracking agents might be preferable for testing linewire resins.) Thus the stress-cracking test, as usually performed, can indicate which of a number of resins has the best crack resistance, but it does not usually show how much better it is. A tester is free to choose any test condition which suits his convenience and objectives except when the method is being used to satisfy a specification or approximate a service environment.

Application of Test Results

The use of the test results is restricted by considerations of the type of article, type of polyethylene and effect of fabrication conditions.

Type of Article

This test method was originally devised by Bell Telephone Laboratories to simulate conditions likely to be encountered in service by polyethylene cable jacket (2). Due to relaxation of the polymer, the applied stress fades with time, while the strain remains essentially steady. This is not comparable to the service stress history of polyethylene pipe, where the creep of the plastic under the influence of the internal pressure results in hoop stresses which increase with time. Caution should therefore be exercised when it is desired to use the results of this test to predict the stress-crack resistance of pipe made from two different polyethylenes. The polyethylene with the faster relaxation rate will fare better in the test, where its stresses will fade more rapidly, but a faster relaxation will likely lead to a more rapid stress rise, and perhaps an earlier failure, in pipe. The danger of being misled by the test results is diminished to some extent if the test is completed within a relatively short time. Stress relaxation will not be so important a factor in 1 hr as in an experiment which lasts a week, at a comparable temperature. The application of test results to polyethylene pipe is further complicated by the fact that stress levels in the test and in pipe in service are very different. Relative resistances to environmental stress-cracking are not necessarily the same under different stress conditions.

The intent of this test is to remove molded-in stress and then impose a controlled applied stress. This more or less approximates the service stress conditions likely to be encountered by wire and cable coatings and pipe. Injection moldings, on the other hand, are

not subjected in normal use to applied stresses of the same magnitude as the residual stresses left by the molding operation. These are a function of the moldability of the resin, which is not evaluated by this test. Unless their environmental stress-crack resistance is very poor, most injection-molded articles are more likely to fail in service by delamination or by cracking around the sprue than by environmental stress cracking of the type measured by this test. Even when stress cracking does occur, the relative order of merit of different resins will more likely be determined by their residual stress levels than by their crack resistance as measured by this method. The application of this test method to injection-molding resins appears to be of doubtful validity (7).

Type of Polyethylene

Specimens are deformed to a standard shape in this test method. The more linear polyethylenes require higher stresses than "normal" polyethylenes to make them conform to this shape. The resulting heavier loads result in more stress-cracking, provided the specimen is not stressed beyond its elastic limit. If the elastic limit is exceeded, the cold-drawn high-density polyethylene becomes more resistant to stress-cracking. For these reasons the bent strip test described here is strictly applicable only to resins with nominal densities about 0.925 g per ml and less. The test may be extended, with caution, to slightly higher density ranges, but the results are probably unreliable when applied to Ziegler and Phillips type polymers. ASTM Method D 1693 covers only low-density polyethylene.

Effect of Fabrication Conditions

The data in Tables IV and VII show how very sensitive environmental stress-crack resistance is to sample conditioning. Since the two experimental conditioning methods differ only in rates of cooling from the melt, it is evident that relatively minor changes in fabrication conditions can have a pronounced influence on the environmental stress-crack qualities of a polyethylene article. An additional complication results from the fact that quenched articles are probably not stable but change with time toward a fully annealed texture. For this reason, the crack resistance of most polyethylene articles, which are cooled rather quickly during their formation, would be expected to decrease (tend toward that of annealed specimens) as the articles age.

The textures produced by slow- and fast-cooled conditioning (3) are intended to be extremes. Texture here refers to relative proportions of crystalline and amorphous material (reflected in the density) and degree of order and strain in intercrystalline and interspherulitic regions. The textures of polyethylene articles are expected to be somewhat intermediate between these two. Since there is such a wide difference in the crack resistance of specimens cooled at the two different rates, the measured values are of very limited use for bracketing the properties of a fabricated article. For example, in one environment listed in Table V, the slow-cooled melt index 2 resin had a median crack time of 7 min, while the same specimen fast-cooled lasted 7 days. Thus the resistance of articles made from this polyethylene to cracking by the specified medium is predicted to be between 7 min and 7 days, provided the stresses and temperatures are comparable to those used in this test. The results of this test method are evidently not suitable for direct engineering application. The test can be useful for deciding which of a number of resins is most crack resistant, but it cannot be applied to the prediction of the service life of polyethylene articles.

Acknowledgments:

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Movement of Sodium with Water in Neat Portland Cement

By R. C. HALL and J. M. RHODES

Movement of sodium in neat cement was studied by the aid of radioactive tracer techniques. Sodium was distributed through a slice having dimensions 1 by 1 by about 0.1 in. thick. This slice was subjected to high humidity on one side and low humidity on the other. Sodium was found to accumulate on the side of dry atmosphere.

The slice was then placed in atmospheric air, and the surface concentrations tended to approach one another.

These are considered as evidence that: (1) sodium moves freely with water in cement, (2) a portion of the sodium tends to be bound (at least to some degree) with the cement and is thus immobilized, and (3) sodium tends to distribute itself with uniform concentration through a mass of concrete.

It is known that various components of cement move through the mass of hardened portland cement paste. W. C. Hanson, for example, has pointed out that alkalis from cement clinker readily go into solution in the liquid phase and that these dissolved substances can diffuse through the liquid phase of the hardened paste.¹

WORK was undertaken to evaluate diffusion coefficients by establishing concentration gradients of sodium in neat portland-cement paste. Procedures consisted of pouring the cement into a form about 4 in. wide, 6 in. long, and 4 in. deep. Test specimens were then sawed from the cast block. These specimen blocks were 1 in. square and 2 in. long. The test specimens were submerged in a water solution of sodium chloride to which a trace of radioactive sodium-22 had been added. After a suitable holding time, the test specimen was removed and a series of thin slices, about 0.1 in. thick, was cut from the square ends. Length measurements were made such that the depth of the faces of these slices, measured from the initial surfaces, could be calculated. These slices were placed on suitable size planchettes and the activities determined in a counter with low gamma and high beta efficiencies. Standard procedures for background corrections were made. Blank planchettes were prepared (from radioactive solutions) and used to make corrections for half-life changes on the cement slices. Since the beta half thickness is very small, the beta concentrations was used as an index of relative surface (instantaneous) concentration. The plot of corrected counts *versus* depths was

used as the concentration gradient curve.

In some of the initial work of making counts of radioactivity on surfaces of these slices, an initial count was made, the slice was laid aside for a period of time, perhaps a day or so, and counts again were taken. It was observed that these later counts seemed to run consistently higher than the initial counts.

For example, on April 14, 1958, a concentration gradient was established as shown in the accompanying graph, Fig. 1. The slices were then held at room conditions until April 16 and new counts made on the same slices. The slices were then held under room conditions until Aug. 11, 1958, when new

counts were again made. Since the slices were not exposed to any source of sodium during the holding time in air and since there was no apparent place where the sodium could have been removed to, it may be concluded that the total quantity of sodium in a slice remained constant. Since there was obviously an increase in sodium on the surfaces, it may be concluded that there must have occurred a depletion of sodium inside the slices.

In order to point this out, the curves for April 16 and August 11 are shown with dips between points, and the curves are shown as dotted lines. The integrated area under the dotted lines should be equal to the integrated area under the solid line for April 14. Thus, the total degree of dips should be appreciably greater than shown. Results, as shown in Fig. 1, clearly indicate that there was an increase in activity on the surfaces of the slices with passage of time.

There are at least two possible ways to explain this observation: (1) water evaporated from the surface thus decreasing the absorption of radiant energy per linear unit of depth of the cement, and (2) water evaporated from the surface and deposited the salts on the surface of the cement. In (2) the salts would be expected to translocate from the interior of the cement to the exterior regions and accumulate at the points where the water evaporated. It



RAYMOND CLARENCE HALL, prior to joining the faculty of Kansas State University in 1951, served for five years with the Army Corps of Engineers during World War II and was in private contracting work in central Montana for two years. He has a wide range of research interests including such subjects as fundamentals of solid-solid mixing, influence of sonic pulses on rates of mass transfer and behavior of solid particle movement in fluids. The work reported herein is a part of an over-all effort to gain basic knowledge on how substances move in cement. Mr. Hall feels that radioactive tracer techniques afford an excellent tool to this end.



JOHN MARK RHODES received his B.S. in Chemical Engineering at Kansas State University in 1959. At present he is studying toward the Ph.D. at the University of Tennessee. Mr. Rhodes is especially interested in the use of statistics as a tool to bring complex systems with many variables under control so they may be experimentally investigated with high efficiency of effort and minimum expense.

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¹ W. C. Hanson, "Hydraulic Cement for Water Tanks and Pipe Lines," ASTM BULLETIN, No. 232, Sept., 1958, p. 52 (TP 199).

is also possible that both effects may occur simultaneously.

Experimental evidence was obtained to support the translocation mechanism as a means of explaining the increase in radioactivity of the slice surfaces with time.

After the three slices were taken, on April 14, 1958, from block 120-1, the remainder of the block was allowed to stand under room conditions until Aug. 12, 1958. On Aug. 12, two slices were taken from the uncut end (end 2) of the block. The resulting concentration gradient is plotted in Fig. 1. A day later, on Aug. 13, counts were again made on these same slices and the resulting concentration gradient plotted.

It was noticed that a thin, white,

reasonable to assume that they received the same treatment with regard to movement of salt and liquid into the block; both ends should then have yielded the same concentration gradient. An examination of the curves clearly shows a steeper concentration of radioactive substances toward the outer edge of end 2 when compared with end 1. This is construed as meaning that the sodium moved toward the outer edges during the period of time while the block was stored at room conditions. While no records were taken on actual drying conditions, it seems reasonable to assume that drying of the block took place during this period.

Comparison of concentrations on Aug. 12 and Aug. 13 of end 2 at depth

at the 0.000-in. depth. This may be interpreted as meaning that the sodium exhibited a tendency to distribute itself uniformly through the slice.

With these evidences as background to indicate that the sodium moved with the water, an experiment was designed to study this movement more closely. A slice of cement, containing radioactive sodium was mounted such that a moist atmosphere existed on one side and a dry atmosphere on the other side (see Fig. 2). Provision was made such that the quantity of water which moved through the slice could be measured. Activity measurements on both surfaces were made at various times.

Results, as described below, showed that the sodium moved with the water. Also, after a high accumulation of sodium was obtained on the dry side, the slice was placed in atmospheric conditions, such that both sides were exposed to the same humidity for a period of time. It was interesting to note that the sodium tended to redistribute itself toward uniform concentration. This was in accord with the observation made on the 0.000- and 0.096-in. surfaces of the first slice as mentioned above.

The surface slice from end 1 (slice 1) of block 120-3 was mounted on a plastic

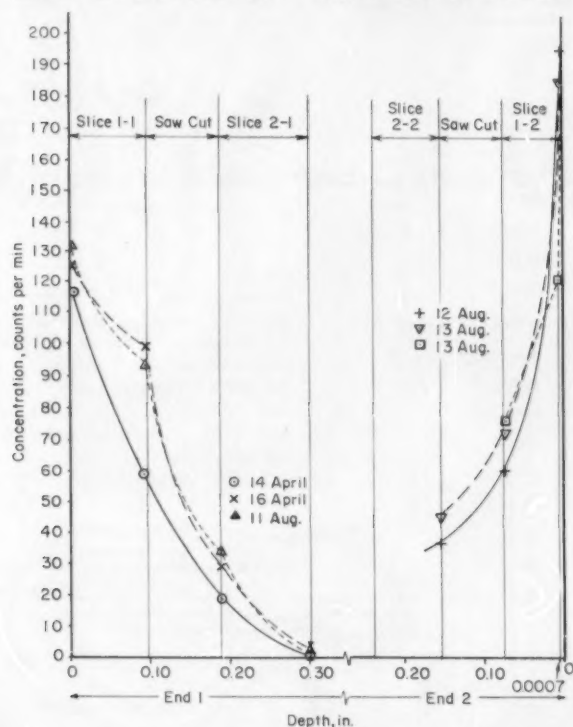


Fig. 1.—Concentration gradient of sodium in cement and changes in point concentration with time.

powdery-like material was deposited on the surface of these later slices, especially on the outer side of the first slice. This surface was rubbed on a piece of emery cloth and a new count made. Measurements with a precision micrometer indicated that 0.0007 in. was removed by the emery cloth. An appreciable drop, as shown in the plot of Fig. 1, was noted in the activity of this surface. Since the block was cast at one time in the same form and was cut from the same regions of the cast, it is reasonable to assume that both ends of the block were homogeneous in all respects. Likewise, since both ends were subjected to the same solution and for the same period of time, it is

reasonable to assume that they received the same treatment with regard to movement of salt and liquid into the block; both ends should then have yielded the same concentration gradient. An examination of the curves clearly shows a steeper concentration of radioactive substances toward the outer edge of end 2 when compared with end 1. This is construed as meaning that the sodium moved toward the outer edges during the period of time while the block was stored at room conditions. While no records were taken on actual drying conditions, it seems reasonable to assume that drying of the block took place during this period.

Comparison of concentrations on Aug. 12 and Aug. 13 of end 2 at depth 0.06 in. again reveals the trend toward increase in concentration of a surface after exposure to the atmosphere. The extreme drop in surface concentration, after removal of the 0.0007-in. layer, clearly demonstrated an extremely high accumulation of sodium on the exposed surface. This was interpreted as meaning that the sodium moved with water from the interior and deposited in the cement at the point where evaporation occurred.

It is also interesting to note the relative magnitude of increase in surface activities on the first slice of end 1. Between April 14 and April 16 the increase in activity at the 0.096-in. depth was appreciably greater than the increase

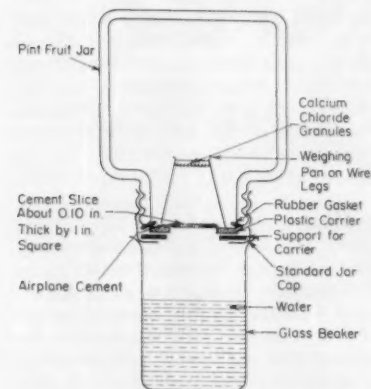


Fig. 2.—Method of supporting cement slice so as to maintain dry atmosphere on one side and water-saturated atmosphere on the other side.

(Plexiglas) carrier. The carrier was of diameter such that it would just fit into a larger planchet. A square hole was cut into the center of the plastic disk such that the 1 in. square cement slice would fit snugly into it. The cement slice was then sealed to the Plexiglas with airplane cement.

The plastic disk was mounted in the lid of a pint fruit jar. A small pan, containing calcium chloride, was mounted on a wire stand with legs. This stand was placed on the fruit jar lid, the jar inverted and screwed onto the lid. This provided a calcium chloride dry atmosphere on the upper side of the slice of cement. The jar was then placed over an open beaker of water, as

shown in Fig. 2, to provide a moist atmosphere (near saturated) on the lower side of the cement slice. Quantity of moisture which moved through the cement slice was determined by gravimetric measurements of the calcium chloride. The cement slice was mounted into the plastic holder. On Nov. 13, 1958, counts were taken on the upper and lower side of the slice. The slice and holder were then held at atmospheric conditions until Nov. 15 when counts were again taken and the weight of the calcium chloride determined. The slice was then assembled in the jar as shown in Fig. 2. On Nov. 18 the jar unit was disassembled, counts on both surfaces of the slice made, weight of the calcium chloride determined, and the unit reassembled. On Nov. 25, this procedure was repeated but reassembly was not made, the slice was stored in atmospheric conditions until Dec. 13 when counts on both surfaces were again made.

The data are given in Table I. Usually three or four counts were taken, one immediately after the other, on a given surface. The largest share of variability in these data may be attributed to instrument characteristics. These data are presented graphically in Fig. 3.

While observations on a single slice may not be considered as sufficient evidence to form definite conclusions, certain tentative conclusions may be drawn. Such tentative conclusions can be used as a valid basis for selection of specific items for further study and as an aid in design of future experiments.

Changes in surface concentrations, on both surfaces, between Nov. 13 and Nov. 15 followed the trend previously observed, that is, when stored under atmospheric (drying) conditions, the activity on the surface increased as the drying increased. It was further observed that the rate of increase of surface activity was greatest on the surface that had the least activity.

Another observation which may have considerable significance can be drawn by comparing the surface activities of Nov. 25 with those of Dec. 13. During this period, the side with low concentration gained in sodium and the side with high concentration lost in sodium. This occurred while both sides were subjected to atmospheric conditions; the lower (water) side would be expected to lose water and the upper (calcium chloride) side would be expected to gain water when exposed to air of normal humidity. These changes were of relatively small magnitude but the statistics of the radioactive counts indicate (at a low level of probability) that the change did occur.

At least two explanations may be proposed to explain why the increase in activity with time was greater on the

TABLE I.—STORAGE CONDITIONS AND SURFACE ACTIVITIES.

Date	Storage Conditions	Average Activity Upper side (Dry Air)	Counts per 5 min. Lower Side (Moist Air)	Background	Total
Nov. 13	Nov. 13 to Nov. 15. Store in room air.	471 -244 227	736 -244 492	244	719
Nov. 15	Nov. 15 to Nov. 25. Apply calcium chloride atmos- phere above and water be- low.	580 -229 351	770 -229 541	229	892
Nov. 18	Nov. 15 to Nov. 25. Apply calcium chloride atmos- phere above and water be- low.	1292 -265 1027	517 -265 252	265	1279
Nov. 25	Nov. 25 to Dec. 13. Store in room air.	1302 -247 1055	432 -247 185	247	1240
Dec. 13		1208 -238 970	566 -238 328	238	1298

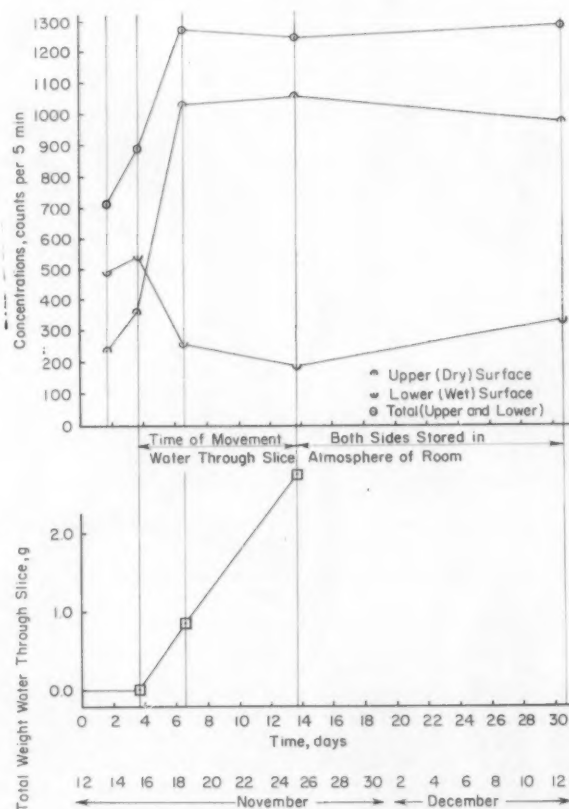


Fig. 3.—Surface concentrations, water through put, time observations.

side of lower concentration than it was on the side of higher concentration. Either the salt tended to distribute itself uniformly through the mass of the cement or the rate of drying and the quantity of water removed may both

have been higher on the surface of lower concentration. In the slice which was exposed to high humidity on one side and low humidity on the other side, the latter explanation may be valid. However, on slice 1, as plotted in Fig. 1,

and on the slice as plotted in Fig. 3 for Nov. 13 to 15, it is reasonable to assume that both surfaces were initially at the same moisture content. Since the observed trends in all three cases were consistent, it is believed that the sodium does tend to distribute itself uniformly through the cement paste.

No readings of quantity of water which passed through, or of surface activities were made during the first few hours (Nov. 15 and 16) during which

the water passed through the cement slice. However, if one attempts to place a smooth and continuous curve through the surface concentrations on Nov. 15, 19, and 25 it immediately becomes apparent that the sodium moved very rapidly during the first few hours and then began rapidly to approach a stagnant value. This occurred under conditions of substantially constant rate of water flow. It would appear, from this, that the rate of sodium

transfer was high during the early stages of movement of water but decreased rapidly to a very low rate (very close to zero rate) in the later stages although an appreciable portion of the sodium remained in the paste. From this, one can conclude that a portion of the sodium is very mobile in the mass of the paste and that a portion of the sodium is bound to at least some degree, to the interior portions of the cement.

Technical Note

An Alignment Block and Clamp for Capillary Viscometers

IN THE determination of kinematic viscosity, errors can be caused by poor vertical alignment of capillary viscometers. This note describes construction details for a holder and alignment block, suitable for Cannon-Fenske viscometers, that can reduce such errors. The holder can be modified for other types of capillary viscometers.

Theory

Normal operating conditions for a capillary viscometer are given by

$$v = Ct \dots \dots \dots (1)$$

when kinetic-energy corrections are negligible.

From Poiseuille's law

$$v = \frac{\pi D^4 h g t}{1.28 L V} \dots \dots \dots (2)$$

where:

- v = kinematic viscosity, centistokes,
- D = capillary diameter, cm,
- h = vertical height between the two liquid levels in the viscometer, cm,
- g = gravitational constant, cm per sec²,
- t = time of flow of fluid in viscometer, sec,
- L = capillary length, cm,
- V = volume of fluid passing through

Diagram of Equation (3)

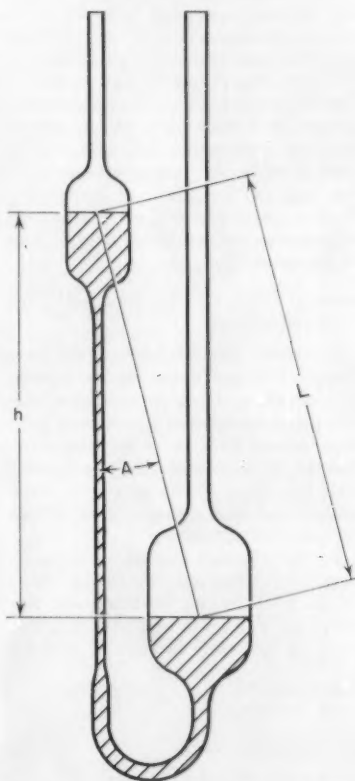


Fig. 1.—Schematic diagram of capillary viscometer.

capillary in time t , cu cm, and

C = viscometer calibration constant, centistokes per sec.

Combining Eq (1) and (2)

$$C = \frac{\pi D^4 h g}{1.28 L V} \dots \dots \dots (3)$$

Hence the calibration constant C is proportional to height h .

With most capillary viscometers the fluid to be tested is allowed to drain from an upper vessel to a lower vessel through a capillary tube. Let L be the distance between the centers of the fluid surfaces in these vessels (Fig. 1). On dropping a vertical line from the center of the surface in the upper vessel, an angle A is formed between these two lines. Then the value of h in Eq (3) may be determined by

$$h = L \cos A \dots \dots \dots (4)$$

If the viscometer is rotated to positions a few degrees on either side of the vertical, L will remain constant but A will vary. Therefore, from Eq (4)

$$dh = -L \sin A dA \dots \dots \dots (5)$$

and combining Eqs (4) and (5)

$$\frac{dh}{h} = -\tan A dA \dots \dots \dots (6)$$

Where dh is the change in h caused by the rotation of the viscometer dA degrees from the vertical position.

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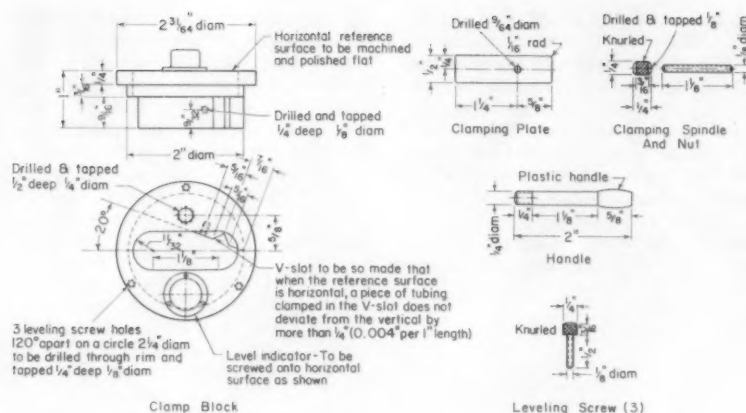


Fig. 2.—Construction details of viscometer holder and alignment block.

In order to fulfill the accuracy requirements of ASTM Method D 445,¹ dh/h must not exceed 0.002 for routine work or 0.001 for viscometer calibration purposes. As a consequence,

$$-\tan A dA \leq 0.001 \dots (7)$$

When A equals 0, which is the case for suspended level viscometers and the Cannon-Fenske viscometer for transparent liquids, $\tan A$ equals 0. For this same viscometer, dh/h equals 0.001 when dA is 2.5 deg.

For the Cannon-Fenske viscometer for opaque liquids, A is 12.3 deg for the top bulb and 9.2 deg for the bottom bulb. Thus, dh/h equals 0.001 for the top bulb when dA is 0.27 deg, and dh/h equals 0.001 for the bottom bulb when dA is 0.35 deg. It is therefore apparent that this viscometer must not vary by more than 0.27 deg from the vertical position.

Construction of Viscometer Holder

Construction details for the holder and alignment block are given in Fig. 2. It will be found that the bulk of the work is in the manufacture of the clamp block. The block consists essentially of an upper section of two concentric cylinders which locates the holder in a stepped hole at the top of the viscometer bath, and a lower section consisting of an off-center segment into which a V-slot is cut, the whole block being machined from solid brass or bronze.

The top of the block is machined flat to provide a horizontal reference surface. The end tubes of the viscometer pass through an elongated hole in the

block. Three leveling screws are placed around the edge of this block so that the reference surface can be adjusted to a horizontal position. A handle screws into the upper surface to enable the block to be easily removed or placed into the bath; the plastic top on the handle is to prevent contact with hot metal if the holder is used in high-temperature baths. Sufficient space is also available on the upper surface for a level indicator.

The viscometer is clamped to the lower segment of the block. The clamping spindle is screwed into the $\frac{1}{8}$ -in. hole in the segment, and the reference arm of the viscometer is clamped into the V-slot by the clamping plate and nut. The V-slot must be machined in such a manner that when the reference arm is clamped it is within 0.27 deg of the vertical when the reference surface on the top of the block is horizontal. Each viscometer holder can then be used for any viscometer without errors of any consequence.

General Hints on Operation and Modifications

1.—This holder has been designed for Cannon-Fenske transparent and opaque viscometers, and it is intended that the filling arm be used as a reference arm. As a consequence, it is essential that the viscometers be standardized either with this type of clamp or by some method that uses this arm as a vertical reference for alignment.

2.—No attempt should be made to clamp more than one arm to the block. To do so is to risk breaking the viscometer. The lower clamping segment has been purposely inclined to the slot

so that the clamping plate will not obstruct the unclamped arm, which should be centered in the slot (that is, not touching any metal parts).

3.—If the clamped reference arm has a large diameter, the clamping plate should be bent so that the face touching the reference arm is parallel to the face of the clamping block.

4.—Modifications to the slot size and shape and to the position of the clamping spindle would allow other types of viscometers to be used. The top may also be altered to suit other types of viscometer baths.

5.—The choice of material for this holder may be influenced by the possibility of corrosion. This, of course, depends upon the fluid used in the viscometer bath and the temperatures involved. If light alloys are contemplated, the weight of the holder must be sufficient to overcome the buoyancy of the viscometer in the bath.

6.—For a level indicator for the reference surface, Fig. 2 indicates a bubble over liquid under a spherical surface. This may be permanently screwed onto the reference surface, or one indicator may be used for several holders.

7.—If one level indicator is used for several holders, both surfaces must be cleaned of any dust or grit.

8.—If the level is screwed onto the holder, it may be necessary to insert a washer of insulating material between the holder and the level indicator if high operating temperatures are contemplated, otherwise the indicator may fracture from expansion of the sealed fluid.

9.—The holder can be checked for alignment by clamping a length of straight glass tubing in the V-slot. Suspend a plumb line through the center of the tube, and adjust the reference surface to horizontal. The deviation of the plumb line from the glass tubing must not exceed 0.004 in. per 1-in. length of tubing in any direction, for a tolerance of 0.25 deg.

10.—With the tolerances allowed in the manufacture of this holder (vertical within ± 0.25 deg), the maximum variation in the viscometer constant C in Ep 1 will be ± 0.1 per cent for a Cannon-Fenske viscometer for opaque liquids. For Cannon-Fenske viscometers for transparent liquids, the variation of C will be ± 0.0008 per cent.

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¹ Method of Test for Kinematic Viscosity, 1958 Book of ASTM Standards, Part 7, p. 201.

The Gravimetric Determination of Strontium Oxide in Portland Cement

By C. L. FORD

Determinations of the strontium oxide content of portland cements make possible more accurate calculations of the potential tricalcium silicate contents thereof. The study of four methods reported below for gravimetric analysis for strontium was made to find one that could be used or modified to give good results in the determination of the small amounts of strontium present in cement. The method selected is based on the extraction of calcium nitrate with 80 per cent nitric acid from the dry mixed nitrates of calcium and strontium, and the quantitative determination of the residual strontium nitrate. The accuracy of the procedure was demonstrated by analyzing high calcium samples to which known small amounts of strontium had been added. The method used is described briefly in the body of the report and a more detailed procedure is presented in the Appendix.

WHEN portland cement is analyzed by usual procedures such as ASTM Method C 114¹ strontium oxide is determined with, and reported as, calcium oxide. The percentage of strontium oxide, however, is usually quite small. Diamond (1)² and Bean (2) have reported that analyses of 203 cements by flame photometry showed that while one contained as much as 0.39 per cent strontium oxide, the mean value was only 0.13 per cent. Bean showed, though, that a strontium oxide value of 0.38 per cent could cause an error of as much as 1.6 percentage points or a rounded-off value of 2 percentage points, in the calculated potential tricalcium silicate content if the calcium oxide was not corrected for strontium oxide.

As a part of one of the studies being made by the Portland Cement Association Laboratories, it became desirable to know the strontium oxide content of a group of 30 cements. Since there is no ASTM procedure for strontium, it was decided to make the analyses by at least two methods. For one, the flame photometric method developed by Diamond (1) was used, since he had demonstrated good accuracy in his report. For a second method, a search revealed several gravimetric procedures, but none was very adaptable to cement with its small amount of strontium. The author's studies, however, led to the modification of an old method to such an extent that good results could be

obtained for as little as 0.1 per cent or less of strontium oxide in cement.

An advantage of the gravimetric method as developed is that the need for the costly flame photometric equipment is eliminated.

Experimental

The gravimetric methods investigated are based on the differential solubility of calcium and strontium (and barium) nitrates in an alcohol-ether mixture, or in monobutyl ether of ethylene glycol, or in strong nitric acid. Most of the experimental work described below was carried out with synthetic mixtures of known strontium and calcium content. A few tests were made by the alcohol-ether method, (3) but it was soon discarded, partly because of the long time required for the analysis and partly because of the flammability of the reagents. Further, Hillebrand, et al., (3) state that the results for strontium by this method are high.

A few tests were also made using a method suggested by Barber (4) (primarily for qualitative analyses) depending on the solubility of calcium nitrate and the insolubility of strontium nitrate in monobutyl ether of ethylene glycol.³ Since filtration was found to be very difficult, and the recoveries of known

amounts of strontium were much too low, the tests were discontinued.

Of the two methods cited (3) using nitric acid to separate strontium as the nitrate, the method of Willard and Goodspeed (5) was studied first. Their procedure specified the addition of 100 or 90 per cent nitric acid to a water solution of the mixed nitrates of calcium and strontium. The calculated volume of acid was added dropwise (with vigorous mechanical stirring) until the solution contained 79 to 80 per cent nitric acid. Stirring for 45 min was recommended for strontium present in amounts of less than 5 mg. However, the author found that with the smaller amounts present in cement, precipitation was incomplete or did not occur at all even with prolonged stirring. In some tests, known amounts of strontium were added during the preparation of the sample, but precipitation was again incomplete. No way was found to adapt the method to the very small amounts of strontium in cement; hence it was abandoned.

The other method using nitric acid, that of Rawson (6) called for the extraction of calcium nitrate with 70 to 80 (preferably the latter) per cent nitric acid from a mixture of the dry nitrates. Although Rawson apparently worked with relatively large amounts of strontium (100 mg or more), the author found it possible to modify the method to separate the 2 mg or less of strontium oxide present in 500-mg samples of cement from the approximately 300 to 325 mg of calcium oxide also present.

In all the tests reported below the mixed oxides of calcium and strontium

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¹ ASTM Method of Chemical Analysis of Portland Cement, 1958 Book of ASTM Standards, Part 4, p. 63.

² The boldface numbers in parentheses refer to the list of references appended to this paper.

³ Known commercially as Butyl Cellosolve.



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(obtained and treated as described under "Procedure") were converted to nitrates. Attempts to extract the calcium in the cold from the mixed nitrates according to Rawson's method were unsatisfactory because the use of even a large amount of 80 per cent nitric acid and long stirring failed to dissolve all of the calcium nitrate from some samples. The procedure was then modified by heating the mixture of nitrates and nitric acid until all the calcium nitrate appeared to dissolve. Unfortunately, at elevated temperatures (near the boiling point of the solution) the small amount of strontium nitrate also dissolved and reprecipitated incompletely or not at all with slow cooling and prolonged stirring. The method of heating and stirring was found to be critical.

The modification that proved to be satisfactory was started by heating the nitrate-nitric acid mixtures until the nitrates were only partly dissolved. The optimum temperature was found to be about 80 to 82 C. The heating was followed by immediate and very vigorous stirring of the mixture for about 5 min, then stirring at a somewhat slower rate for a total of 30 to 60 min. This procedure resulted in complete solution of the calcium nitrate and reprecipitation of any strontium nitrate that might have gone into solution during heating. Only in the case of samples containing less than 0.5 mg of strontium oxide was the precipitate found to be low by a few hundredths of a milligram—a negligible amount. A brief description of the procedure, applicable to portland cement, is given below. A more detailed method is presented in the Appendix.

Procedure

Separate successively from a 0.500-g sample of cement: silica, the ammonium hydroxide group, manganese, and calcium and strontium oxalates by the usual methods for the analysis of portland cement. Exceptions: the ammonium hydroxide group and the oxalates need not be reprecipitated unless they are to be used as part of the general analysis of a cement sample. Ignite the oxalates in a platinum crucible to calcium and strontium oxides.

Transfer the ignited oxides quantitatively into a 150-ml beaker. (See the Appendix for more details of the method of transfer.) Convert the oxides to nitrates by adding slowly to the covered beaker about 3 ml of nitric acid (70 per cent diluted 1:1). Wash down the sides of the beaker and then cover. Evaporate to near dryness, then dry completely in an oven at 130 to 140 C.

Prepare 80 \pm 1 per cent nitric acid from reagent grade fuming (90 per cent) nitric acid as follows: First check the

TABLE I.—STRONTIUM OXIDE (SrO) DETERMINED IN THE PRESENCE OF 320 MG CALCIUM OXIDE ADDED AS 572 MG CALCIUM CARBONATE.

Strontium Oxide							
Sample	Added mg	Found, mg				Difference	
		Test 1	Test 2	Test 3	Average	mg	Per cent ^a
No. 1.....	0.25	0.20	0.15	..	0.18	-0.07	-0.01
No. 2.....	0.50	0.59	0.44	0.49	0.51	+0.01	0
No. 3.....	0.75	0.78	0.73	..	0.76	+0.01	0
No. 4.....	1.00	1.22	1.03	0.98	1.07	+0.07	+0.01
No. 5.....	2.00	2.07	..	..	2.07	+0.07	+0.01
Average.....						+0.02	

^a Percentage differences if weight of SrO shown is based on 0.5-g samples of cement.

TABLE II.—STRONTIUM OXIDE (SrO) DETERMINED IN THE PRESENCE OF THE 316 MG CALCIUM OXIDE CONTENT OF A PORTLAND CEMENT.

Sample	Added mg	In 0.5 g Cement mg	Total Present mg	Strontium Oxide			Difference	
				Found, mg				
				Test 1	Test 2	Average	mg	Per cent ^a
No. 1.....	None	0.05	0.65	0.05	0.05	0.05		
No. 2.....	0.50	0.05	0.55	0.49	0.49	0.49	- 0.06	- 0.01
No. 3.....	1.00	0.05	1.05	1.03	1.08	1.06	+ 0.01	0
No. 4.....	1.50	0.05	1.55	1.52	1.62	1.57	+ 0.02	0
No. 5.....	2.00	0.05	2.05	2.06	2.11	2.09	+ 0.04	+ 0.01
Average.....							+ 0.01	

^a Percentage differences if weight of SrO shown is based on 0.5-g samples of cement.

TABLE III.—STRONTIUM OXIDE CONTENT OF PORTLAND CEMENTS BY GRAVIMETRIC AND FLAME PHOTOMETRIC METHODS.

Cement	Strontium Oxide, per cent							Differences
	Gravimetric Method				Flame Photometric Method			
	Test 1	Test 2	Test 3	Average	Test 1	Test 2	Average	
No. 11.....	0.333	0.333	0.313 ^b	0.33	0.38	0.37	0.38	+0.05
No. 11T.....	0.352	0.304	0.333 ^b	0.33	0.37	0.37	0.37	+0.04
No. 12.....	0.254	0.294	0.254 ^b	0.27	0.29	0.29	0.29	+0.02
No. 12T.....	0.254	0.274	0.274 ^b	0.27	0.29	0.28	0.29	+0.02
No. 13.....	0.049	0.088	0.078 ^b	0.07	0.09	0.08	0.09	+0.02
No. 14.....	0.088	0.000 ^c	0.059 ^b	0.07	0.09	0.08	0.09	+0.02
No. 15.....	0.088	0.078	0.078 ^b	0.08	0.08	0.08	0.08	0.00
No. 16.....	0.254	0.225	0.254 ^b	0.24	0.25	0.24	0.25	+0.01
No. 16T.....	0.235	0.206 ^c	0.245 ^b	0.24	0.26	0.25	0.26	+0.02
No. 17.....	0.127	0.108	0.059 ^{b,c}	0.12	0.11	0.11	0.11	-0.01
No. 18.....	0.039	0.049	0.049	0.05	0.05	0.05	0.05	0.00
No. 18 TR.....	0.020	0.029	0.029	0.03	0.05	0.05	0.05	+0.02
No. 19A.....	0.127 ^{b,c}	0.186 ^b	0.176	0.18	0.17	0.18	0.18	0.00
No. 19B.....	0.142 ^b	0.127 ^b	0.157	0.14	0.18	0.19	0.19	+0.05
No. 19C.....	0.137 ^b	0.166	0.127	0.14	0.18	0.18	0.18	+0.04
No. 21.....	0.137 ^c	0.078	0.059	0.07	0.08	0.08	0.08	+0.01
No. 21T.....	0.068	0.049	0.059	0.06	0.08	0.08	0.08	+0.02
No. 22.....	0.206	0.215	0.226	0.22	0.23	0.23	0.23	+0.01
No. 23.....	0.137	0.108	0.137	0.13	0.17	0.17	0.17	+0.04
No. 24.....	0.059	0.098	0.069	0.08	0.11	0.12	0.12	+0.04
No. 25.....	0.040	0.020	0.039	0.03	0.06	0.07	0.07	+0.04
No. 31.....	0.137 ^c	0.235	0.235	0.24	0.27	0.27	0.27	+0.03
No. 33.....	0.029	0.020	0.039	0.03	0.06	0.06	0.06	+0.03
No. 33T.....	0.029	0.039	0.010	0.03	0.06	0.06	0.06	+0.03
No. 34.....	0.039	0.000 ^c	0.029	0.03	0.05	0.06	0.06	+0.03
No. 41.....	0.098	0.059 ^c	0.107	0.10	0.11	0.11	0.11	+0.01
No. 42.....	0.020	0.010	0.010	0.01	0.04	0.04	0.04	+0.03
No. 43.....	0.108	0.049 ^c	0.127	0.12	0.12	0.12	0.12	0.00
No. 43A.....	0.137	0.117	0.147	0.13	0.13	0.14	0.14	+0.01
No. 51.....	0.039	0.059 ^b	0.059	0.05	0.06	0.06	0.06	+0.01
Averages.....				0.13			0.15	+0.02

^a Differences of average flame photometric from average gravimetric values.

^b In preparing the sample for test, the ammonium hydroxide group was reprecipitated.

^c Values not included in averages.

exact concentration of the 90 per cent acid from its specific gravity and temperature using specific gravity tables. Mix thoroughly the volumes of acid and water calculated to give 80 per cent acid. Cool, then check the concentration to be sure that 79 to 81 per cent acid has been obtained.

To the cooled nitrates, prepared as above, add about 90 ml of 80 per cent nitric acid, then heat slowly so that the mixture will reach a temperature not exceeding 80 to 82 C in 6 to 8 min. Remove the beaker from the hot plate and immediately stir mechanically for 5 min as vigorously as possible without

spattering, then stir somewhat less rapidly for the total periods shown below.

NOTE: The rate of heating, the temperature, and very rapid stirring during the first 5 min are critical for a successful separation. This part of the procedure as well as the stirring times, although somewhat empirical, were found to give the best results.

SrO content, per cent	Stirring time, min
Under 0.06	60
0.06 to 0.10	45
0.11 to 0.15	40
0.16 to 0.20	35
Over 0.20	30

If the approximate strontium oxide content is not known, stir for 60 min. Let stand overnight.

Filter into a tared, fritted glass, 15-ml crucible (medium porosity), transfer and wash the precipitate with 80 per cent nitric acid, and dry at 130 to 140 C to constant weight as strontium nitrate.

Make a blank determination following the above procedure and correct the strontium nitrate value accordingly. Calculate to per cent strontium oxide.

Discussion

Effect of Barium

In the absence of sulfate ion, barium nitrate would be separated by the above procedure along with strontium, but portland cement contains sufficient calcium sulfate so that any traces of barium present in the cement would be separated as barium sulfate prior to the precipitation of calcium and strontium.

Effect of Sulfate Ion

The possibility of coprecipitation of some of the strontium as the sulfate with the ammonium hydroxide group was considered. The presence of sulfate ion from the cement did not appear to affect the results of the tests reported in Table II. The cement used in these tests contained 1.5 per cent sulfur as sulfur trioxide. Further the ammonium hydroxide group was reprecipitated (thus eliminating practically all the sulfate ion before the second precipitation) in 16 of the tests reported in Table III. These data are indicated by^a. It will be observed that this change in the procedure did not cause a consistent difference in the strontium oxide content from that of samples prepared with a single precipitation. In other words, strontium was not lost by precipitation as the sulfate with the ammonium hydroxide group.

Tests of Method

Two sets of tests were made to determine the accuracy of the method. A stock solution of strontium chloride, prepared by dissolving 1.4247 g of reagent grade strontium carbonate in dilute hydrochloric acid (1:1) and dilut-

ing to one liter, was used as a known source of strontium. This stock solution contained the equivalent of 1.0 mg of strontium oxide per ml.

1. In the first set of tests, 572 mg of reagent grade calcium carbonate were used in each test to simulate 64.0 per cent of calcium oxide in a 500-mg cement sample. Amounts of strontium stock solution varying in equivalent strontium oxide content from 0.25 to 2.00 mg, as shown in Table I, were added to the calcium carbonate. This range of strontium content covered the amounts which according to Bean's data (2), would likely be found in 500 mg of cement. The strontium and calcium were converted to nitrates by the addition of dilute nitric acid (70 per cent, diluted 1:1) followed by evaporation to dryness. The analyses for strontium were carried out as described above. All values were corrected for blank determinations. It will be observed from Table I that the average "found" values for strontium oxide differed by 0.07 mg or less from the "added" values. This difference is equivalent to only 0.014 per cent in 500-mg samples of cement.

2. The second set of tests was performed to determine whether any strontium was lost in the separations made in a cement analysis prior to the determination of strontium, and to further test the accuracy of the method. Amounts of strontium stock solution varying in equivalent strontium oxide content from 0.00 to 2.00 mg, as shown in Table II, were measured into beakers and evaporated to dryness. Five hundred milligrams of a very low strontium (0.01 per cent) cement were added to each. The analyses were carried out as described above under "Procedure." All values were corrected for the results of blank determinations. The values given in Table II show that the differences between the amount of strontium oxide found and the sum of strontium oxide added, plus strontium oxide in the cement, did not exceed 0.06 mg, or the equivalent of 0.012 per cent of the cement.

Effect of Calcium

Further observation of Tables I and II shows that all the slight differences are positive with the exception of the sample in each set with the lowest strontium content. Willard and Goodspeed (5) found by their method that some calcium was precipitated with the strontium where the amount of the former was high; reprecipitation produced more accurate results. Work by the author, however, following his modification of Rawson's method (6) resulted in much too low values when the above samples were reprecipitated. While the possibility of coprecipitation of calcium cannot be entirely excluded, it

appears from the results shown in Tables I and II that the above modification gives very good results with a single precipitation. The slightly low values for the very low strontium samples were probably due to failure to attain complete reprecipitation of some of the strontium nitrate that went into solution when the mixture was heated.

Analyses of Cements

The strontium analyses of the 30 cements referred to earlier are shown in Table III. It will be noted that the average gravimetric value of 0.13 per cent is 0.02 percentage points lower than the average flame photometric value of 0.15 per cent. This difference of only 0.02 percentage point served to confirm the photometric results. Further, it is believed, on the basis of the data presented in Tables I and II, that the results obtained by the gravimetric method (Table III) not only confirmed but were more accurate than those by flame photometry.

The assumption of somewhat greater accuracy for the gravimetric method is based on indirect evidence. The differences on a percentage basis between "added" and "found" amounts of strontium oxide given in Tables I and II, last columns, were 0.01 per cent or less. Since nearly two-thirds of the differences shown in Table III exceeded the above 0.01 per cent, it was assumed that the photometric results were farther than the gravimetric from the true values.

The individual test data are presented in Table III to show the relative precision of the two procedures. It will be noted that the photometric method shows better precision. However, as previously stated, the gravimetric test is not only probably more accurate, but may be made with simple laboratory apparatus.

Time Requirements

The time required for the gravimetric method is somewhat greater than for the photometric. Starting with the ignited oxides (obtained as part of a general analysis), the actual working time for a single sample is about 50 to 80 min with an elapsed time of about 1 day (evaporation, standing overnight, drying, etc.). By the photometric method, starting with the dry cement sample, the working time is about 50 min with an elapsed time of about 70 min (assuming standard solutions have been prepared and the flame photometer "warmed up" and calibrated).

Limitations of Method

The gravimetric procedure described above provides only for the determination of acid-soluble strontium (as is also the case with the photometric method). However, if the strontium determina-

tion is made as a part of an ASTM referee analysis wherein the silica is volatilized and the residue is dissolved and added to the filtrate from the silica both soluble and any insoluble strontium can be determined.

Summary

Methods were studied for the gravimetric determination of the strontium content of portland cement. The one

selected was developed by modifying an existing method so as to permit the determination of the small amounts of strontium present in cement. The method is based on the solubility of calcium nitrate and the insolubility of strontium nitrate in 80 per cent nitric acid. The accuracy of the procedure was demonstrated by analyzing samples of known low strontium content. Calcium did not appear to interfere with

the analyses. Analyses of 30 cements gravimetrically and flame photometrically showed results averaging 0.02 percentage point higher by the latter method. Although the gravimetric method is the slower of the two, the tests reported using known amounts of strontium showed that it gives good accuracy. A valuable feature of this latter procedure is that it does not require costly apparatus.

APPENDIX

Gravimetric Method for the Determination of Strontium Oxide in Portland Cement⁴

Scope

1. This method is intended to cover the separation and determination of the small amount of strontium oxide precipitated and weighed with calcium oxide in the usual course of a cement analysis.

Apparatus

2. (a) *Crucible*, 15-ml, low-form, fritted-glass, medium-porosity, made of heat- and chemical-resistant glass.⁵

(b) *Suction Apparatus*.

(c) *Wash Bottle*, all-glass (except for the bulb).

Reagents

3. (a) *Ammonium Chloride Solution* (20 g per liter).—Dissolve 20 g of reagent grade ammonium chloride (NH_4Cl) in water and dilute to 1 liter.

(b) *Ammonium Oxalate Solution* (1 g per liter).—Dissolve 1 g of reagent grade ammonium oxalate ($(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$) in water and dilute to 1 liter.

(c) *Nitric Acid* (80 \pm 1 per cent).—Prepare from reagent grade 90 per cent fuming nitric acid (HNO_3). First, check the actual concentration from specific gravity and temperature readings, using specific gravity tables. Calculate the amount of dilution water required to give a concentration of 80 per cent. After dilution and cooling, check the concentration of the diluted acid.

(d) *Nitric Acid* (1:1).—Mix 1 volume of reagent grade concentrated nitric acid (HNO_3 , 70 per cent) with 1 volume of distilled water.

Preliminary Separations

4. (a) *Silicon Dioxide*.—Separate the silicon dioxide (SiO_2) from a 0.500-g portion of the sample in accordance with Section 33 of the Standard Methods for Chemical Analysis of Portland Cement (ASTM Designation: C 114-58).¹ Discard the precipitate.

(b) *Ammonium Hydroxide Group*.—Separate the ammonium hydroxide group in accordance with Section 9 of Standard Methods C 114, modified as follows: Do not reprecipitate; after the precipitation, filter, scrub the beaker once; then wash

the precipitate and filter paper eight times with ammonium chloride solution (20 g per liter). Discard the precipitate.

(c) *Manganese Dioxide*.—Separate and discard in accordance with the procedure described in Section 13 (a) of Standard Methods C 114 for calcium oxide.

(d) *Calcium and Strontium Oxides*.—Separate in accordance with Section 13 of Standard Methods C 114, modified as follows: Do not reprecipitate. After filtering, rinse the beaker thoroughly twice with cold ammonium oxalate solution (1 g per liter); then wash the filter paper and contents about ten times with the wash solution. Dry the precipitate and paper in a platinum crucible, char the paper without inflaming, burn the carbon, and finally ignite in a muffle furnace at 1050 C for 30 min. Reserve the ignited precipitate for the determination of strontium oxide (SrO) (Note 1).

NOTE 1.—The weighed precipitate obtained after ignition of calcium (and strontium) oxide in the course of a complete analysis of cement may also be used for the determination of SrO.

Procedure

5. (a) Transfer the ignited precipitate quantitatively, by thorough brushing (NOTE 2) into a 150-ml beaker. Cover the beaker. Add (if not previously added to the crucible) slowly about 3 ml of HNO_3 (1:1). Wash the cover and the sides of the beaker with a minimum of water. Place the beaker (uncovered) under an infrared lamp or on a steam bath and evaporate to as near dryness as possible; then place in a drying oven at 130 to 140 C for at least 1 hr or until all appearance of moisture has disappeared.

NOTE 2.—If careful examination of the crucible shows that any precipitate still remains in it, add about 3 ml of HNO_3 (1:1) and wash into the 150-ml beaker with a minimum of water and with care to prevent spattering of the precipitate in the beaker.

(b) Cool the beaker for a few minutes; then add about 90 ml of HNO_3 (80 per cent). Heat slowly on a hot plate so that the mixture will reach a temperature up to but not exceeding 80 to 82 C in 6 to 8 min. Remove the beaker from the hot plate and immediately stir with a mechanical stirrer for 5 min as vigorously as possible without spattering, then stir somewhat less rapidly, to dissolve calcium nitrate and leave strontium nitrate in suspension (NOTE 3). If the approximate strontium oxide content is known,

the stirring time shall be as shown below, otherwise stir the mixture for 60 min.

SrO Content, per cent	Stirring Time, min
Under 0.06.....	60
0.06 to 0.10.....	45
0.11 to 0.15.....	40
0.16 to 0.20.....	35
Over 0.20.....	30

Regardless of the amount of strontium present, however, stir long enough to dissolve all particles of calcium nitrate ($\text{Ca}(\text{NO}_3)_2$). (NOTE 4). After stirring, let stand overnight.

NOTE 3.—The rate of heating, the temperature, and very rapid stirring for about 5 min immediately after heating are critical for a successful separation of calcium and strontium.

NOTE 4.—The relatively large particles of calcium nitrate may be readily distinguished from the finely divided, cloudy-appearing strontium nitrate in suspension in the mixture.

(c) Filter, using suction, into a tared (NOTE 5) fritted-glass crucible. Transfer the precipitate to the crucible by washing from the beaker three times with a vigorous stream from a wash bottle containing HNO_3 (80 per cent). Wash the crucible and precipitate ten times with small portions of the same HNO_3 solution. Place the crucible in a drying oven at 130 to 140 C for about 2 hr. Cool in a desiccator and weigh as strontium nitrate ($\text{Sr}(\text{NO}_3)_2$). Repeat the drying to a constant weight (NOTE 5).

NOTE 5.—Weighings must be made with great care, since the weight of the crucible is very great compared to the weight of the contents.

(d) *Blank*.—Make a blank determination, following the same procedure and using the same amounts of reagents, and correct the results obtained in the analysis accordingly.

(e) *Calculation*.—Calculate the percentage of strontium oxide to the nearest 0.01 as follows:

$$\text{SrO, per cent} = W \times 97.93$$

where:

W = grams of $\text{Sr}(\text{NO}_3)_2$, and
97.93 = molecular ratio of SrO to $\text{Sr}(\text{NO}_3)_2$ (0.48964) divided by the weight of sample used (0.5 g) and multiplied by 100.

⁴ The method was developed by adaptation of, and addition to, parts of two previous methods (5,6) described by Hillebrand, Lundell, Bright and Hoffman (3). Preliminary separations are based on ASTM Method C 114.

⁵ Pyrex has been found satisfactory for this purpose.

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The Use of 2,2,4,4,6,8,8-Heptamethylnonane as a Primary Diesel Fuel

By T. W. MEARS, R. M. DAVID, and F. L. HOWARD

REFERENCE hydrocarbons have been used for many years as the primary standards for determining the combustion characteristics of fuels used in engines operating on both spark-ignition and compression-ignition systems.

In 1927, Edgar (1)¹ suggested the use of *n*-heptane and 2,2,4-trimethylpentane (*isooctane*) as the primary reference standards for the spark-ignited fuels. These materials were selected because: they have almost identical boiling points and densities; there is only one methylene group difference in their molecular weights; and, most important, *n*-heptane showed a tendency to detonate more easily than any gasolines used at the time, while 2,2,4-trimethylpentane was more resistant to detonation than any gasoline then in current use. Indeed, it was stated that nearly all fuels would fall between the 40:60 and 60:40 ratios of *n*-heptane to *isooctane*.

These compounds were not available in quantity or high purity in 1927. However, commercial firms have improved them so that they have become available in very high purity and in quantity sufficient to warrant the elimination of secondary reference fuels formerly used in routine testing.

The selection of primary reference standards for the compression-ignited fuels did not come about until later. In 1932, Boerlage and Broeze (2) sug-

Ignition characteristics of blends of 2,2,4,4,6,8,8-heptamethylnonane with *n*-hexadecane (*n*-cetane) are compared with the characteristics of blends of *n*-hexadecane and 1-methylnaphthalene. The ease of preparation and nature of the combustion characteristics indicate that this compound merits serious consideration as an alternate, or even a replacement, for 1-methylnaphthalene as the low-cetane primary reference fuel for rating of diesel fuels for cetane number.



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¹The boldface numbers in parentheses refer to the list of references appended to this paper.

gested the use of α -cetene (1-hexadecene) and 1-methylnaphthalene. The selection of these hydrocarbons seems to have been largely on the basis of "ignition quality," that is, α -cetene had a relatively low spontaneous ignition temperature, while 1-methylnaphthalene had a relatively high spontaneous ignition temperature as compared to fuels in use at that time. The selection of these compounds was unfortunate in several ways that will be pointed out later.

In 1936, Rendel (3) reporting for the Volunteer Group for Compression-Ignition Fuel Research suggested the use of *n*-cetane (*n*-hexadecane) and 1-methylnaphthalene. The reason for this change was the inability to produce α -cetene of consistent quality. The differences in quality were assumed to be a result of the shifting of the double bond during manufacture. Hydrogenation of cetene to cetane removed this difficulty. From the table of properties given in Rendel's paper it would appear that the *n*-hexadecane available at the time was about 87 per cent pure and the 1-methylnaphthalene was a mixture containing about one-third of the isomeric 2-methylnaphthalene and two-thirds 1-methylnaphthalene. For several years, these impure hydrocarbons were used as the standards for the measurement of cetane number. The purity of *n*-hexadecane was raised to about 95 per cent some years ago, and recently 1-methylnaphthalene of comparable purity has become available (4).

The cetane number of a fuel is defined as the volume percentage of *n*-hexadecane in an admixture of 1-methylnaphthalene which gives the same ignition characteristics as the fuel in a standard engine. While combustion is primarily a problem in chemical kinetics and would not be expected to follow rigidly the partial molal laws, it is nevertheless logical that the ignition characteristics of a mixture would be dependent on the relative numbers of component molecules present rather than on the bulk volumes of the components. In the case of *n*-heptane and *isooctane*, the difference between the volume percentages and the mole percentages (relative number of molecules) is not large. However, in the case of *n*-hexadecane and 1-methylnaphthalene the difference is considerable, running as high as 19 units at 60 cetane number. This difference is brought about because 1-methylnaphthalene has a much higher density and lower molecular weight than *n*-hexadecane. The differences between volume percentages and mole percentages are shown graphically in Fig. 1.

It was this large difference between volume and molal percentages, coupled with the rather unsteady running of the engine on blends containing large per-

TABLE I.—PHYSICAL PROPERTIES OF 2,2,4,4,6,8,8-HEPTAMETHYLNONANE, *n*-HEXADECANE, AND 1-METHYLNAPHTHALENE.

	2,2,4,4,6,8,8-Heptamethylnonane	<i>n</i> -Hexadecane, (11)	1-Methylnaphthalene, (12)
Freezing point, deg Cent.....		18.165	-30.480
Boiling point at 760 mm Hg, deg Cent.....	246.90	286.793	244.685
dt/dp at 760 mm Hg, deg Cent per mm.....	0.0591	0.06077	0.06047
Density at 20 C, g per ml.....	0.78448	0.77344	1.02031
Density at 25 C, g per ml.....	0.78117	0.76996	1.01664
Refractive index at 20 C, n_D	1.43990	1.43453	1.61755
Refractive index at 25 C, n_D	1.43786	1.43250	1.61512
Viscosity at 100 C, cs.....	3.258 ^a	3.081 ^b	2.209 ^a
Molecular weight (1957).....	226.448	226.448	142.201

^a Determined by J. A. Walker of National Bureau of Standards.

^b See reference 13.

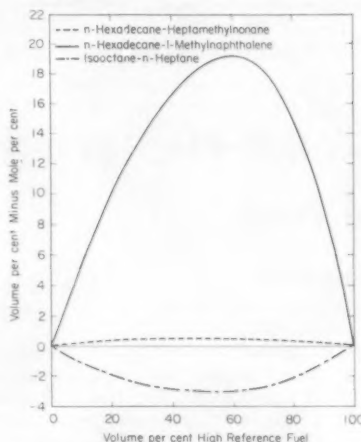
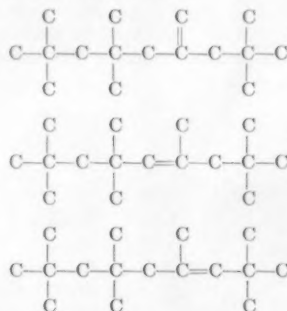


Fig. 1.—Volume per cent minus mole per cent as a function of composition of reference fuel blends.

centages of 1-methylnaphthalene and the difficulty in purifying commercial 1-methylnaphthalene, that led to a search for a new, more suitable substitute for 1-methylnaphthalene as the low primary diesel reference standard. A very promising compound was found to have been prepared and the structure proved at The Pennsylvania State Univ. about 1940 (5, 6, 7, 8). This material was prepared by the dimerization of diisobutylene with a sulfuric acid-acetic acid mixture to yield a mixture of olefins of the following structures:



This mixture of olefins is commonly misnamed "tetraisobutylene." However, it is not the same group of olefins that is obtained by polymerization of

TABLE II.—RATE OF CONVERSION OF DIISOBUTYLENE TO HEPTAMETHYLNONANES.

Time, hr	Refractive Index at 20 C	Heptamethylnonanes, per cent
0.0.....	1.4086	0
5.5.....	1.4143	14.1
23.5.....	1.4379	72.5
28.5.....	1.4457	91.8

isobutylene with a variety of electrophilic catalysts. It may be seen that these olefins, upon hydrogenation, yield only one paraffin hydrocarbon—2,2,4,4,6,8,8-heptamethylnonane.

The hydrogenated product was found to have about the same boiling point as 1-methylnaphthalene, and its cetane number is slightly higher. However, its density is much closer to that of *n*-hexadecane than 1-methylnaphthalene and its molecular weight is identical. For a comparison of the properties of these hydrocarbons, see Table I. From these data it may be shown that the volume percentage and mole percentage of mixtures of *n*-hexadecane and heptamethylnonane are very close to each other (Fig. 1).

Experimental

Preparation of 2,2,4,4,6,8,8-heptamethylnonane

The heptamethylnonane was prepared by the method described by Cosby (5). The starting material was an intermediate cut from the distillation of diisobutylene (9). Freezing point data showed this material to be 97 to 97.5 mole per cent 2,4,4-trimethyl-1-pentene; the principal impurity being 2,4,4-trimethyl-2-pentene.

A charge of 18.5 kg (165 moles) of 2,4,4-trimethyl-1-pentene and 9.5 kg of glacial acetic acid was mixed in a glass-lined reaction vessel and cooled to 10 C. To this was added 2.3 kg of cold concentrated sulfuric acid, followed by 0.5 kg of acetic acid. The balance of the sulfuric acid, 6.5 kg, was added over the next 3 hr and the reaction mixture stirred for 24 hr. During this time the reaction temperature was kept at 12 to 18 C.

During the course of the reaction, small samples were withdrawn periodi-

cally, washed with water, and dried over sodium carbonate. The percentage of conversion to the heptamethylnonane mixture was determined by refractive index as shown in Table II. The value used for the refractive index of the mixture produced by complete dimerization was 1.4490 at 20 C (5).

At the completion of the 28.5 hr, the dark brown acid layer was drawn off. The organic layer was washed several times with water, followed by sodium carbonate solution, and again with water. The neutral organic layer was then steam-distilled in the kettle to remove the light ends. When the water-to-hydrocarbon ratio of the distillate reached 6.7:1 and the refractive index at 20 C reached 1.4487, the steam distillation was discontinued. The organic distillate measured 3900 ml, more than half of which had a refractive index above 1.44. The organic material remaining in the kettle was washed again and dried. A total of 10.5 liters of material was recovered which had a refractive index of 1.4492, which indicates essentially complete dimerization. A simple distillation gave a 90 per cent point of 240.2 C and a dry point of 250.7 C at 760 mm Hg, indicating that very little material higher than C-16 was present.

An attempt was made to hydrogenate this material directly using nickel-on-kieselguhr catalyst. Apparently some poisoning agent was present, for the olefinic mixture failed to absorb the hydrogen. Therefore the crude heptamethylnonanes were distilled at 40 mm Hg pressure in a 36 by 1 in. heligridded column. Only fractions of material having a refractive index at 20 C of 1.4503 to 1.4505 were collected for hydrogenation. This material hydrogenated smoothly at 180 to 190 C at an initial hydrogen pressure of 1800 psi, using nickel-on-kieselguhr catalyst.

The product was percolated through silica gel and distilled on a 36 by 1 in. heligridded column under 50 mm Hg pressure. From these distillations there were obtained two main samples:

TABLE III.—CETANE NUMBERS OF *n*-CETANE-HEPTAMETHYLNONANE BLENDS.

<i>n</i> -Hexadecane in Heptamethylnonane, per cent by volume	Cetane Number	Barometer in. Hg	Wet Bulb, deg Fahr	Dry Bulb, deg Fahr	Hand-Wheel Setting	Compression Ratio	Reference Fuels
75.1.....	79.1	29.66	78	92	1.790	11.05	C-16 ^a -AMN ^b
65.0.....	67.9	29.64	74	83	1.638	12.00	C-16 ^a -AMN ^b
60.1.....	64.1	29.69	77	83	1.623	12.995	C-16 ^a -AMN ^b
50.1.....	55.6	29.55	75	89	1.536	12.73	C-16 ^a -AMN ^b
40.1.....	49.8	29.64	67	71	1.478	13.18	C-16 ^a -AMN ^b
30.0.....	39.8	29.66	73	81	1.365	14.17	C-16 ^a -AMN ^b
20.1.....	31.4	29.69	77	83	1.182	16.235	C-16 ^a -AMN ^b
28.9.....	40.0 (old calibration)				1.365	14.17	T-14 ^c -U-7 ^d
	38.2 (new calibration)						
17.6.....	31.0 (old calibration)				1.139	16.809	T-14 ^c -U-7 ^d
	29.8 (new calibration)						

^a C-16 = *n*-hexadecane.

^b AMN = 1-methylnaphthalene.

^c T-14 = high cetane number secondary reference fuel.

^d U-7 = low cetane number secondary reference fuel.

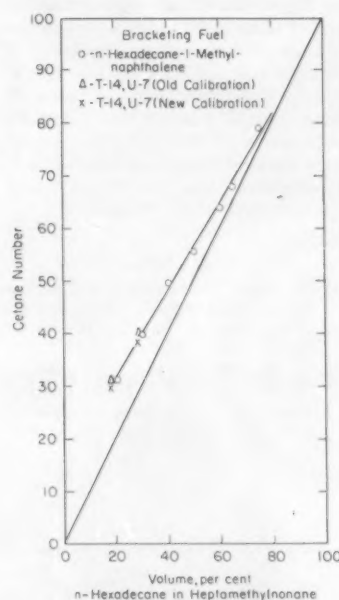


Fig. 2.—Cetane numbers as a function of composition of solutions of *n*-hexadecane and heptamethylnonane.

heptamethylnonane using ASTM Method D 1015.³ None of these was successful. It is thought that the presence of the *d*- and *l*-enantiomorphs arising from the asymmetric 6-carbon atom hinders crystallization to such a degree that the solution congeals to a viscous glass.

Ignition Characteristics of 2,2,4,4,6,8,8-heptamethylnonane

The cetane numbers of blends of *n*-hexadecane and heptamethylnonane were determined by means of ASTM Method D 613.⁴ The test engine (serial No. 345306) had been recently overhauled and run about 35 hr when the rating of these blends began. The equivalent compression ratios were determined by means of a Solartron Ignition-Delay Meter, Model ECS-1.⁵ For the past year, the average deviation of ratings from this laboratory from the average ASTM Diesel-Fuel Exchange Group was ± 0.86 cetane number; the maximum deviations were +1.7 and -1.3 cetane numbers.

The reference fuels used were 95+ per cent *n*-hexadecane and 1-methylnaphthalene.⁶ These materials were examined at the Atlantic Refining Co.⁷ and gave the following analyses:

	Per cent
<i>n</i> -hexadecane:	
<i>n</i> -tetradecane.....	0.6
<i>n</i> -pentadecane.....	1.2
<i>n</i> -hexadecane.....	96.4
<i>n</i> -heptadecane.....	0.7
isomeric pentadecanes and hexadecanes.....	1.1
1-methylnaphthalene:	
total methylnaphthalenes.....	97.5
2-methylnaphthalene.....	1.1
1-methylnaphthalene (by difference).....	96.4
alkylbenzenes.....	0.5
tetralines, indenenes, etc.....	0.5
unknown material M.W. 148..	1.0

The cetane numbers of the heptamethylnonane-*n*-hexadecane blends were determined by bracketing with *n*-hexadecane-1-methylnaphthalene blends. The blends were prepared using calibrated burets. Due to the short supply of primary reference fuels, the individual points were determined only once. Certain heptamethylnonane-*n*-hexa-

No. 1 $n_D^{20} = 1.4400$, 2000 ml; and No. 2, $n_D^{20} = 1.4403$, 3800 ml. Various fore-runs and after-runs were redistilled to yield 400 ml of additional heptamethylnonane, $n_D^{20} = 1.4399$. All samples were finally percolated through silica gel.

Determination of Physical Properties of 2,2,4,4,6,8,8-heptamethylnonane

The physical properties were determined on the best samples reserved from the center of the distillate. The boiling point, density, and refractive index were determined by the method of Mears et al (10). The viscosity was determined by ASTM Method D 445.² The properties determined are listed in Table I, along with those of *n*-hexadecane and 1-methylnaphthalene for comparison.

Several attempts were made to obtain a freezing point of 2,2,4,4,6,8,8-

² ASTM Method of Test for Kinematic Viscosity (D 445-53 T), 1958 Book of ASTM Standards, Part 7, p. 201.

³ ASTM Method of Test for Measurement of Freezing Points of High-Purity Compounds for Evaluation of Purity (D 1015-55), 1958 Book of ASTM Standards, Part 7, p. 469.

⁴ ASTM Method of Test for Ignition Quality of Diesel Fuels by the Cetane Method (D 613-58 T), 1958 Book of ASTM Standards, Part 7, p. 1270.

⁵ Solartron Ignition Delay Meter ECS-1 Handbook, The Solartron Electronic Group, Ltd., Thames Ditton, Surrey, England.

⁶ Manufactured by the Humphrey-Wilkerson Corp., Devine St., North Haven, Conn.

⁷ Analyses were performed by R. A. Brown, Atlantic Refining Co., Philadelphia, Pa., to whom we are grateful for permission to include these data.

decane blends were also rated against the secondary reference fuels T-14 and U-7, using both the old and new ASTM calibrations. The results of these ratings are given in Table III and are shown graphically in Fig. 2.

The points appear to fall on a straight line within the precision of the individual ratings. A least-squares line through the points reproduces them within an average deviation of ± 0.9 cetane units. Since this is the same average deviation as shown by this laboratory in the ASTM Diesel Exchange Group, no attempt was made to fit the points to a higher order equation. This line extrapolated to zero per cent *n*-hexadecane gives a cetane number for 2,2,4,4,6,8,8-heptamethylnonane of 14.7. Extrapolated to 100 per cent *n*-hexadecane, it gives a cetane value of 98.4. It will be noted that a large deviation (+1.6) is at the 75 per cent *n*-hexadecane 25 per cent heptamethylnonane point. This could be indicative of a curvature of the line toward 100 cetane number at the 100 per cent *n*-hexadecane point. There may also be some downward curvature to the line as it approaches zero cetane number. By calculating a cetane number for pure 2,2,4,4,6,8,8-heptamethylnonane based on mole percentages rather than volume percentages we obtain a value of +12.5 cetane number. The *n*-hexadecane-heptamethylnonane number (H.N.) may be related to the ASTM cetane number in the useful range (20 to 80 cetane number) by means of the equation:

$$\text{ASTM cetane number} = 14.7 + 0.8369 \text{ H.N.}$$

The heptamethylnonane shows much less tendency to soften and swell rubber and plastic materials than does 1-methylnaphthalene. Operation of the rating engine is "smoother," especially in the lower cetane number ranges, when heptamethylnonane blends are used rather than 1-methylnaphthalene.

Conclusions

Results indicate that 2,2,4,4,6,8,8-heptamethylnonane may offer certain advantages over 1-methylnaphthalene for use as the low diesel reference standard. It is easily prepared from readily available raw material and easily purified. Over the useful range the cetane number of its blends with *n*-hexadecane are linear with the volume percentage of *n*-hexadecane and may be linearly related to the cetane number based on blends of *n*-hexadecane and 1-methylnaphthalene. The combustion of its blends in the standard engine appears to be "smoother" than the combustion of 1-methylnaphthalene blends.

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Discussion of Paper on Control Testing for Separation of Lightweight Material from Aggregate¹

MR. W. G. HIME,²—The Higginson and Wallace paper is of interest to me since it uses one of the liquids and some equipment and procedures similar to those used in a test developed by ASTM Subcommittee III-c of Committee C-9 on Concrete and Concrete Aggregates, Mr. R. A. Willis, and myself. The most recent version of this Proposed Tentative Method of Test for Cement Content of Freshly Mixed Concrete appeared in the ASTM BULLETIN, July, 1959, pp. 48-49.

Perhaps some of our findings would be of value to the authors.

¹ E. C. Higginson and George B. Wallace, "Control Testing for Separation of Lightweight Material from Aggregate," ASTM BULLETIN, No. 243, Jan., 1960, p. 60 (TP 18).

² Supervisor, Analytical Chemistry Laboratories, Portland Cement Assn., Skokie, Ill.

1. Denatured alcohol according to certain government formulae is used. We find that the regulations necessary to secure such denatured alcohol are cumbersome, to say the least. For our test acetone is used, with good results.

2. The sinking of lightweight aggregate because of heavy liquid absorption is of interest. We will have to investigate this for our method, although our centrifugal operation may eliminate this effect. Since this is a major source of error in the Higginson-Wallace test, perhaps they might try a centrifugal separation. However, the application of the centrifuge to their large-size samples may be inconvenient or completely impractical.

3. In the discussion at the end of the article, comments by Chairman Cum-

mins and Mr. Higginson indicated that a commercial hydrometer was not available. We have been able to obtain hydrometers in the 2.0 to 3.0 specific gravity range from Rascher & Betzhold, Chicago, catalog R-150-230.

MESSRS. E. C. HIGGINSON AND G. B. WALLACE (authors).—In the discussion following the paper, Mr. Delmar Bloem, of the National Ready Mixed Concrete Assn. suggested using varsol in lieu of the perchloroethylene used in our development of the heavy liquid test. We have since tried varsol and find it quite suitable. Varsol is cheaper, easier to obtain, less toxic, less volatile than perchloroethylene, and blends easily with 1,1,2,2-tetrabromoethane to give a heavy liquid having the desired specific gravity for separation of lightweights.

TECHNICAL COMMITTEE NOTES

(Continued from p. 54)

sion indicated a broad and general interest in this subject.

Committee E-12 is studying problems associated with the defining of appearance of carbon paper and typewriter ribbon impressions. A task force has been appointed to undertake this project.

Two recommended practices for goniophotometry will be submitted to the Society for publication as tentative this year. Goniophotometry is a general procedure for evaluating the manner in which materials geometrically redistribute light. One of the recommended

practices deals with transmitting materials and the other with reflecting materials. Neither of the recommended practices will cover absorption characteristics. Methods dealing with color, which arises from spectral selectivity, are now published in the Book of ASTM Standards.

Committee E-12 is considering sponsoring a symposium at one of its future meetings. Topics for this symposium suggested at the meeting are: (1) production-line inspection of appearance, (2) product-designer specification of appearance, (3) color measurement of liquids, (4) relation between design and appearance control, (5) management aspects of appearance control, (6) appearance control for standards and de-

sign engineers, (7) appearance control in industry, particularly graphic arts and textiles, and (8) fundamentals of color education.

First ASTM Radioisotope Test Methods Completed

The first three ASTM test methods using radioisotopes will be recommended by Committee E-10 on Radioisotopes and Radiation Effects for Society publication this year. These are the determination of sulfur content of petroleum products, the determination of magnesium oxide content of portland cement, and the measurement of density and moisture content of in-place soil. Also in final form is a document covering definitions in the field of dosimetry.

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Kodak reports on:

the profit viewpoint on nondestructive testing ... sunshine for the plastics man who worries ... a little literature before the 11 o'clock news

Not too good, not too bad

One lady and 106 gentlemen, all materialists by profession whatever their private spiritual views, have labored long and brought forth two volumes of material philosophy that weigh in about average for newborn babes.

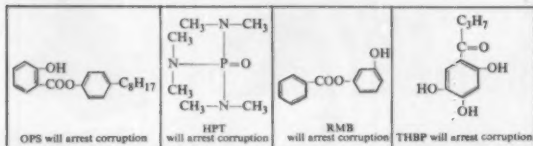
Title: *Nondestructive Testing Handbook*. Editor: Robert C. McMaster, The Ohio State University. Publisher: The Ronald Press Company, New York. Price: \$24. No charge for the applause rendered the work here. What's good for nondestructive testing is good for Kodak.

Nondestructive testing seems to be analytical physics, counterpart to analytical chemistry. The public pictures the "purpose" of chemistry as mostly analyzing things, just as the physicist fashions atom bombs out of cosmic rays. This book shows that physics, too, can have a "purpose" in better, safer, more profitable living. However, the book is not written for the public. Deeply concerned with profit it is indeed.

Too much control of product characteristics squanders resources. Too little squanders reputation. Profit perfumes the happy valley in the middle.

The first section develops these thoughts in a manner to interest and please the management, whether the product is bathtubs or Venus probes. The remaining 53 sections pursue the theme down every crevice of technical detail, not only in our own specialties of film radiography and optical gaging, but in such others as liquid penetrants, magnetic particle tests, electrified particle tests, eddy currents, ultrasonics, brittle coatings, photoelastic coatings, strain gaging, radiation sources, fluoroscopy and x-ray image devices, x-ray diffraction and fluorescence, and even vision itself, properly aided.

Corruption can be arrested



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Isn't it fun how in the chemical industry practically everybody is simultaneously practically everybody else's customer, supplier, and competitor! Data sheets and development samples (for those in a position to evaluate them) from Eastman Chemical Products, Inc., Kingsport, Tenn. (Subsidiary of Eastman Kodak Company).

Metallography and other matters

You would think we had nothing better to do than write letters and be friendly, helpful, and cheerful.

Though this policy hasn't sunk us yet, we do go through motions to put the dispensing of technical photographic wisdom on a slightly self-sustaining basis. For those who have not yet delved deep enough to frame specific questions, we publish what we call *Kodak Data Books* and print on the cover a small cash price, like 50¢.

Just issued is a new one, "Photomicrography of Metals." It contains 13 pages on the metallographic microscope (unbiased toward any particular make of instrument, since we are not in that business), 3 pages on illumination, 5 on filters, 3 on photographic materials (which we do make), 5 on exposure determination, and 8 on processing and printing—just enough for thoughtful perusal between the evening paper and the 11 o'clock news. The pages are meaty; the illustrations are there to explain, not just fill space; the author (anonymous) is a photomicrographer, not an ad-writing hack.

Also just published is the 8th edition of one that has taught many thousands of people since 1933 the rock-bottom facts about the photographic emulsion as a scientific device. The title, "Kodak Photographic Films & Plates for Scientific and Technical Use," dissembles a wee bit. In the old days astronomy was regarded as too thin and unworldly a market to justify commercial literature; therefore the title was devised as a shield from the beady eyes of hard-headed accountants. They find it hard to understand that addressing ourselves to the needs of men with their minds inside stars strengthens the capabilities of photographic technology in general. Indeed, this new 8th edition contains some helpful hints from Mount Wilson and Palomar Observatories that could teach an amateur astronomer to think like a pro. The edition reveals some constriction from the sprawling diversity of *Kodak "Spectroscopic" Plates and Films* hitherto offered, and these pages show how the present lineup fills the bill.

Theoretically the purchase of these data books from your Kodak dealer draws him and you closer together. Those willing to forego the personal touch can obtain them from Special Sensitized Products Division, Eastman Kodak Company, Rochester 4, N. Y., which is also the place to address specific questions.

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Bookshelf

General Methods of Test and Control in the Laboratory. Part I, Geometrical and Mechanical Measurements (in French).

Robert L'Hermite; Eyrolles, 61, Blvd. Saint-Germain, Paris 5, France; 742 pp.; 475 figs.; 16 by 25 cm; 9965 francs (approx. \$20).

Reviewed by A. T. McPherson, Associate Director, National Bureau of Standards, Washington, D. C.

THIS is the first volume of a comprehensive treatise on the laboratory inspection and testing of materials being prepared by L'Hermite in collaboration with members of the staff of the Laboratories of Construction and Public Works, of which he is the director. The introductory chapters deal with the selection of tests and specifications, laboratory design and layout, and the application of statistics to testing. A list of the important laboratories in France and abroad is included.

A chapter on geometric measurements contains methods for length and thickness, area, volume, density, particle size and shape, surface area, porosity, surface texture, and roughness. A chapter on mechanical measurements deals with time, velocity, mass, and force, while a succeeding chapter is

devoted to extensometry with methods for measuring changes in length by means of mechanical, optical, and strain-gage equipment. A final chapter constituting about one-fourth of the volume is devoted to machines for mechanical testing, including equipment for the measurement of stress-strain in tension and compression, torsion, impact, hardness, wear, abrasion resistance, modulus of elasticity, hysteresis, and fatigue. The basic principles on which the machines operate are described fully, as well as their construction, operation, and methods of calibration.

The book is characterized by thoroughness in treating the time-honored as well as the new methods and equipment. The text is clearly written and abundantly illustrated; a feature much to be commended is the inclusion

at the end of each chapter of a list of symbols and their definitions and a well-selected bibliography.

The measurement practices described are those of the practical test engineer rather than those of the physicist. For example, the method for density takes no account of temperature and assumes that the density of water at room temperature is unity.

This volume is one that every testing laboratory and every engineering library should have for reference. On account of the similarity of technical terms in French and English, the book can be used with even a limited knowledge of French.

The second volume that is planned for this series will deal with physical and chemical methods and equipment, including methods for the measurement

(Continued on p. 86)



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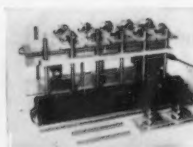
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BOOKSHELF

(Continued from p. 84)

of temperature, humidity, surface tension, viscosity, and optical, thermal, electrical, and radiometric quantities. Succeeding volumes will treat individual materials and products, describing the methods of evaluation and test for each. A final volume on the "pathology" of construction will give examples of incidents and accidents and will discuss their causes and methods of avoiding them.

Proceedings of an international conference on the atomic mechanisms of fracture held in Swampscott, Mass., April 12-16, 1959.

Edited by B. L. Everbach, D. K. Felbeck, G. T. Hahn, and D. A. Thomas; Technology Press of the Massachusetts Institute of Technology and John Wiley and Sons Inc., New York (1959); 646 pp.; illus.; \$17.50.

Reviewed by Robert A. Lad, National Aeronautics and Space Administration, Lewis Research Center.

THE SWAMPSCOTT CONFERENCE provided an opportunity for experimentalists and theorists to join in a discussion of the mechanisms of fracture on an atomic scale. The book is especially valuable because it includes the 27 papers and discussions, as well as summarizing reports of the chairman of each conference. The summarizing reports, by C. S. Barrett, R. W. K.

Honeycombe, and N. J. Grant, are concise presentations of current thinking and future research needs in the fields of cleavage fracture, fatigue and ductile fracture, and high-temperature fracture.

For cleavage fracture, the Griffith hypothesis still appears to be satisfactory as a first approximation and as the basis for further work. Much work must be done before it can become more quantitative. A fundamental understanding of fracture must of necessity be gained by consideration of the atomic mechanisms involved. It is pointed out that the classical theory, which speaks in terms of macroscopic concepts such as yield stress and cleavage strength, bypasses the atomic mechanisms. The theoretical developments based on the idea of dislocation pile-ups at a boundary are an approach that can hopefully lead to quantitative predictions of behavior by starting with fundamental mechanisms and independently measurable material constants.

It is generally agreed that except in special cases, fatigue damage commences at or near the surface of the specimen: surface removal is much more effective than annealing in prolonging fatigue life. A great deal of attention is given to the possible mechanisms for the formation of extrusions and intrusions which are now believed to occur in most places where fatigue failure eventually takes place. The need is emphasized for more work in this area and

in the general area of the metallographic features of fatigue closely correlated with mechanical behavior. The advisability of more work with single crystals is also pointed out.

Several new ideas and facts concerning ductile fracture are presented. Microstructural examination of the neck just prior to cup-and-cone fracture has revealed the formation in the fibrous zone of pores which gradually open up and result in rupture which cannot be described as a propagating crack. Possible mechanisms for the formation of such pores are discussed. Also discussed are the importance of grain size and the orientation of the specimen with respect to the bar from which it is machined.

The portion of the conference devoted to high-temperature fracture emphasized grain-boundary sliding and the roles of void formation, grain-boundary migration, and dislocation pile-ups in initiating fracture. It is pointed out that present theories of grain-boundary sliding are not yet capable of predicting either the point of fracture or how it originates. It is also evident from the discussion that the role of the atmosphere in high-temperature testing deserves more attention than it has received in the past.

This book is well worth careful examination by anyone interested in the details of the present state of our knowledge of the fracture phenomenon.

(Continued on p. 88)

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Other Societies' Events

- April 24-28—The American Ceramic Society, Hotel Bellevue-Stratford, Philadelphia, Pa.
- April 25-27—Constructions Specifications Inst., Ricky's Studio Inn, Palo Alto, Calif.
- April 25-27—Association of Iron and Steel Engineers, Spring Conference, Sheraton Hotel, Philadelphia, Pa.
- April 25-29—American Society for Metals, 2nd Southwestern Metal Exposition and Congress, State Fair Park, Dallas, Tex.
- April 25-29—American Welding Society, Annual Meeting and Welding Exposition, Hotel Biltmore, Los Angeles, Calif.
- May 1-5—Electrochemical Society, Spring Meeting, La Salle Hotel, Chicago, Ill.
- May 2-3—Society of Petroleum Engineers of AIME, Wichita Falls, Tex.
- May 3-5—American Public Power Assn., Annual Meeting, Shoreham Hotel, Washington, D. C.
- May 5-6—Engineering Mechanics Div., American Society of Civil Engineers, Conference on Structural Mechanics, Purdue University, Lafayette, Ind.
- May 7-13—Society of the Plastics Industry, National Conference and Annual Meeting, Cruise on Queen of Bermuda.
- May 9-12—American Petroleum Inst., Division of Refining, 25th Midyear Meeting, Sheraton-Cadillac and Statler Hotels, Detroit, Mich.
- May 9-12—Instrument Society of America, Conference and Exhibit, Civil Auditorium and Brooks Hall, San Francisco, Calif.
- May 9-13—American Foundrymen's Society, Congress and Exposition, Convention Hall, Philadelphia, Pa.
- May 12-14—American Institute of Industrial Engineers, National Conference, Dallas-Sheraton Hotel, Dallas, Tex.
- May 15-20—American Water Works Assn., Annual Convention and Exhibit, Americana Hotel, Bal Harbour, Miami Beach, Fla.
- May 16-18—Copper and Brass Research Assn., Annual Meeting, Homestead, Hot Springs, Va.
- May 16-20—National Fire Protection Assn., Annual Meeting, Montreal, Canada.
- May 18-20—Society for Experimental Stress Analysis, Spring Meeting, Severin Hotel, Indianapolis, Ind.
- May 20-29—Organization of American States, 8th Pan American Highway Congress, Bogota, Columbia.
- May 22-25—National Association of Purchasing Agents, Convention and Inform-A-Show, Biltmore Hotel, Los Angeles, Calif.
- May 23-26—Building Officials Conference of America, Annual Conference, Eden Roc Hotel, Miami Beach, Fla.
- May 24-26—American Society for Quality Control, Annual Convention, Sheraton-Palace Hotel, San Francisco, Calif.
- May 25-26—American Iron and Steel Inst., General Meeting, Waldorf Astoria Hotel, New York, N. Y.

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BOOKSHELF

(Continued from p. 86)

Flat Rolled Products: Rolling and Treatment

Edited by T. Dancy and E. L. Robinson; Metallurgical Society Conferences, Vol. I, Interscience Publishers, Inc., New York and London (1959); 128 pp.; illus.: \$3.75.

Reviewed by E. P. Beachum, Assistant Metallurgical Engineer, Bethlehem Steel Co.

THIS is the Proceedings of a technical conference sponsored by the Mechanical Working Committee of the Iron and Steel Division, The Metallurgical Society, and the Chicago Section, AIME. The conference covered two broad fields—the rolling of flat-rolled products (primarily sheet and strip), and the heat treatment of these products. The first two papers cover rather comprehensive and thorough investigations of factors affecting the profile of the continuous mill product, with an interpretation of the observed results according to accepted rolling mill theory. A round-table discussion of surface texture problems follows.

The practical aspects of a continuous normalizing furnace are followed by the theory of, and experimental observations on, continuous sheet annealing cycles. Two papers on recently developed methods of heating coils and continuous strands end the conference.

The tone of the papers varies from the very practical question-and-answer session to the theoretical background of annealing and rolling. On the whole, the coverage is thorough although sometimes narrow in scope. The book should be of interest to that large array of people who either manufacture or fabricate the products of these somewhat prodigious continuous flat rolling mills. An index would have increased its usefulness.

Research Highlights of the National Bureau of Standards

Annual Report 1959, National Bureau of Standards Miscellaneous Publication 229; (Order from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.); 169 pp.; 55 cents.

Adapted from publisher's description.

THIS ILLUSTRATED report brings together the most important developments in the research program of the Bureau during 1959. It describes a wide range of scientific studies, laboratory experiments, and instrumentation developments arising from the Bureau's responsibility for leadership in the science of measurement.

Progress is reported in the calibration of instruments for measuring very high temperatures and pressures. Bureau researchers are also studying the behavior of materials at pressures up to 1,500,000 psi.

Other research reported includes the refinement of atomic standards of length and frequency, confirmation of the Rydberg constant, establishment of a vibration pickup calibration service, and special measurements of the heat conductivity of explosives and solid propellants.

Special efforts are reported on the properties of materials at high temperatures. Some of these studies deal with solid-state reactions in high-temperature alloys, refractory coatings for aircraft and missiles, and new cements for high-temperature strain gages.

The report also summarizes the Bureau's calibration, testing, and standard samples programs, publications program, and cooperative research with industry. A brief summary of some of the programs planned for the coming year is included.

Structure and Properties of Thin Films

Edited by C. A. Neugebauer, J. B. Newkirk, and D. A. Vermilyea; John Wiley and Sons, Inc., New York (1959); 561 pp.; illus.: \$15.

Reviewed by M. J. Sinnott, Professor of Chemical and Metallurgical Engineering, University of Michigan.

THIS BOOK is the record of the complete proceedings of an international conference on thin films sponsored jointly by the Air Force

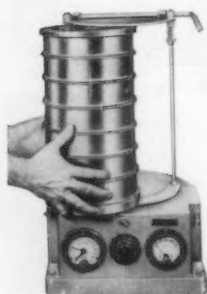
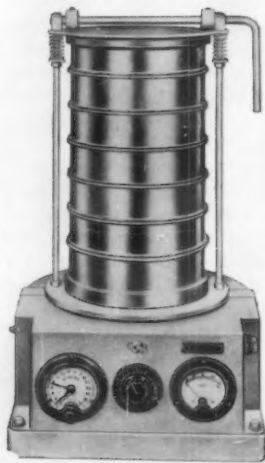
(Continued on p. 90)

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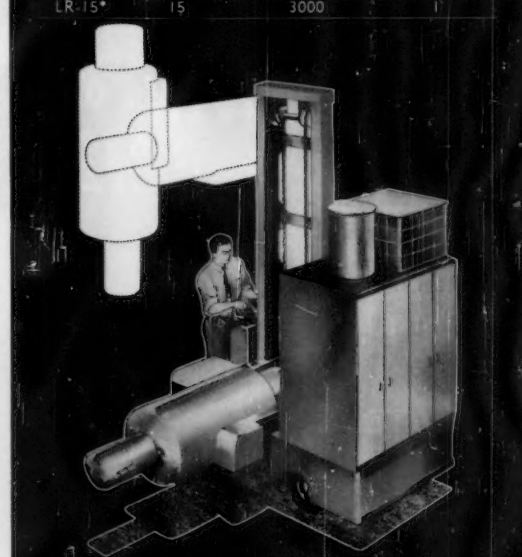


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BOOKSHELF

(Continued from p. 88)

Office of Scientific Research and the Research Laboratories of the General Electric Co. at Lake George, N. Y., in September, 1959.

The study of thin films inevitably leads to the study of surface phenomena, and both of these fields are for the most part made up of large uncharted areas in which activity has been growing over the last ten years. The reviewer would guess that the function of the conference was to bring together all those interested in surface and film phenomena with an eye to exchanging information in the hope that progress in these fields would thereby be accelerated. From the scope and variety of the papers which constitute this volume it is doubtful if any marked acceleration of synthesis in these fields will occur for some time. This is due to the variety of driving forces which are motivating researchers in these fields. One group is concerned with the formation of the films themselves: the mechanism of nucleation and growth, epitaxy with underlying substrates, the structural perfection or imperfection, surface areas, binding energies, and similar items. Another group is concerned primarily with the physical properties of the films. This second group can be subdivided into subgroups interested in mechanical, electrical, and magnetic properties. Still another group is in-

terested in what might be termed the surface chemistry of films: the kinetics of adsorption, diffusion, oxidation, catalytic effects, and similar phenomena.

The general pattern of presentation in this book is to place a lead or summary type of paper at the head of a group of papers in each of the five groups of topics listed above. These papers are then followed with specific articles which illustrate the range of research in each of the fields and go more deeply into specific areas. While the lead articles do an excellent job of reviewing the literature in a given area and summarizing the current research, the follow-up articles do not always appear to be related to the lead articles. The articles on electric and magnetic properties form more of a continuum than do the articles on growth, mechanical properties, and chemical properties. Electrical engineers in particular will be interested in the papers on the electrical and magnetic properties, since in their drive toward miniaturization of electronic components they will eventually find that they are dealing with films and surfaces and it would be well to know what pronounced changes do occur in what are generally believed to be structural insensitive properties.

The general engineer will probably have only passing interest in this book, since the areas covered are quite specialized. On the other hand, for those who are becoming interested in various phases of surface phenomena, the book fulfills a real need in that it brings to-

gether under one cover all the materials that have been scattered through the various physics and chemistry journals and generally escape the notice of the engineers.

Nonwoven Fabrics—An Unbiased Appraisal

Published by Nonwovens Assoc., Cambridge, Mass.; (Written by nine recent graduates of the Harvard Business School); mimeographed; 143 pp.; \$15.

Adapted from publisher's description.

This is a report of a comprehensive study of fabrics produced through bonding individual fibers together by chemical, mechanical, or thermal means, without the need for yarn interlacings. The report is designed to provide a complete, unified picture of the nonwoven fabrics industry of today, and to present an objective preview of the potential problems and opportunities for this field in the future. Included are chapters on: manufacture, finishing and dyeing, fibers, binders, applications, research and development, marketing, and implications for the future. In the appendices to the report are discussions of the patent and secrecy implications in the nonwovens field, as well as listings of patents and companies, a detailed bibliography, index, and glossary of technical terms.

(Continued on p. 102)

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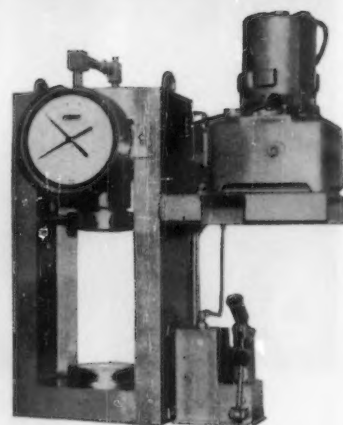
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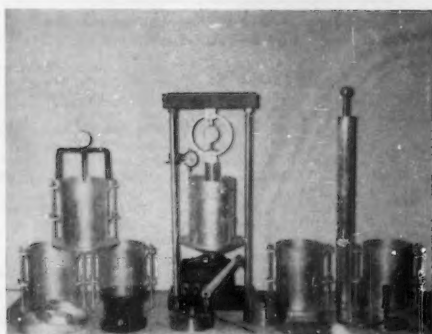


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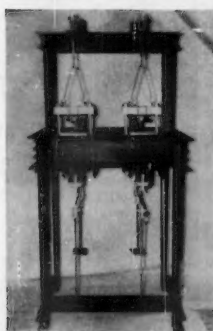
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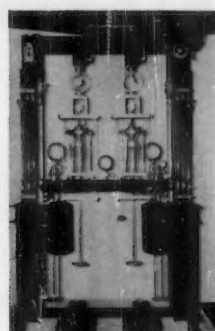
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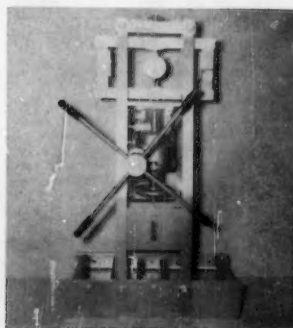


Triaxial

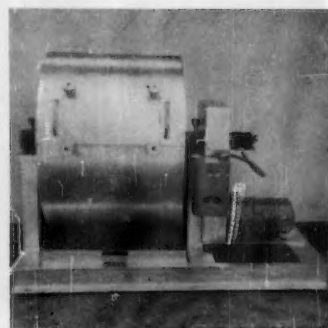
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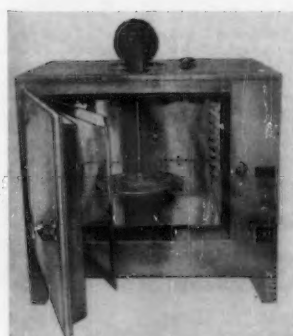


Flexure

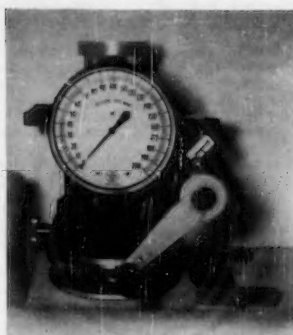


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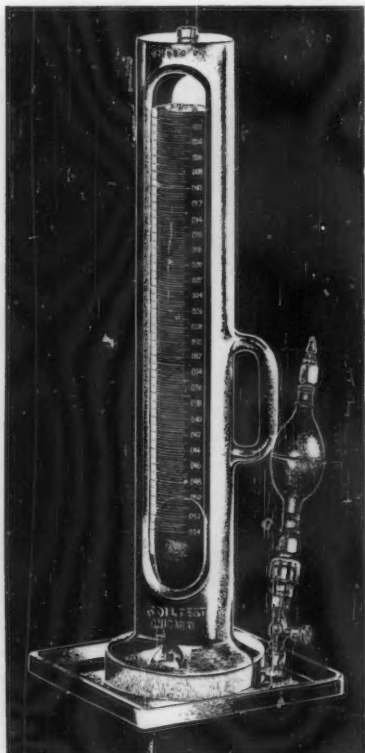
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Ceramaseal, Inc., Box 25, New Lebanon
Center, N. Y.

Chicago District

Prestressed Concrete Inst., Norman L. Scott,
executive secretary, 205 W. Wacker Dr.,
Chicago 6, Ill.

Brightly, Charles F., maintenance engineer,
Brightly Galvanized Products, Inc., 3330
S. Cicero Ave., Cicero 50, Ill.

Brotherson, Donald Edward, research assist-
ant professor of architecture, Small Homes
Council, University of Illinois, 31 E.
Armory, Champaign, Ill. [A]*

Dwyer, James C., sales manager, Voss Engi-
neering, Inc., 5649 N. Ravenswood Ave.,
Chicago 26, Ill.

Eddy, Robert T., junior engineer, Bendix
Products Div., Bendix Aviation Corp.,
401 N. Bendix Dr., South Bend 20, Ind.
For mail: 19570 Dubois Ave., South
Bend 17, Ind. [A]

England, Howard F., general supervisor,
specifications, U. S. Steel Corp., Gary
Steel Works, Gary, Ind.

Erickson, Stephen E., director of beneficia-
tion, The M. A. Hanna Co., Box 720,
Hibbing, Minn. For mail: 2106 Tenth
Ave., Hibbing, Minn.

Euler, George M., manager, advanced
components engineering, Hotpoint Co.,
Division of General Electric Co., 227 S.
Seeley Ave., Chicago 12, Ill.

Forbes, Isaac G., engineer of buildings,
Illinois Central Railroad Co., 135 E.
Eleventh Pl., Chicago 5, Ill.

Frankel, M. F., director of engineering and
manufacturing, Galland & Henning Mfg.
Co., 2756 S. 31st St., Milwaukee 46, Wis.

Frey, Raymond M., chief chemist, Kyle
Products Plant, Line Material Industries,
Ninth and Marion Aves., South Mil-
waukee, Wis.

Geigel, M. J., chief metallurgist, Chromium
Mining and Smelting Corp., 13550 S.
Indiana Ave., Chicago 27, Ill.

Greengard, Charles W., owner, Charles W.
Greengard Associates, 730 Waukegan Rd.,
Deerfield, Ill.

Harding, Brent T., chief engineer, Industrial
Div., Midwest Oil Co., 2500 Minnehaha
Ave., Minneapolis 4, Minn.

Henning, Norman E., vice-president and chief
engineer, Twin City Testing and Engineer-
ing Laboratory, Inc., 2440 Franklin Ave.,
St. Paul 14, Minn.

Herzig, Clifford L., chemist, Abrasive Div.,
Albertson and Co., Inc., Le Mars, Iowa.
[A]

Hoover, James M., assistant professor, civil
engineering, Iowa State Univ., Ames,
Iowa. For mail: R.F.D. No. 3, Ames,
Iowa.

Hotelling, Williams W., Jr., county engineer,
LaSalle County Highway Dept., Box 212,
Ottawa, Ill. For mail: 10464 Birch-
lawn Pl., Ottawa, Ill. [A]

Johnson, A. Stanford, general planning
engineer, Oscar Mayer and Co., Inc.,
Madison 1, Wis.

Koch, John B., director of engineering, Ameri-
can-Standard Industrial Div., Kewanee
Plant, 101 Franklin St., Kewanee, Ill.

McBroom, Edward T., control dept., Central
Soya Co., Inc., 1825 N. Laramie Ave.,
Chicago 39, Ill.

McBroom, John, president, Stainless Foundry
and Engineering, Inc., 5132 N. 35th St.,
Milwaukee 9, Wis.

Mistic, George, chief application engineer,
The Gudeman Co., 340 W. Huron St.,
Chicago 10, Ill.

Mohr, Joseph S., Jr., assistant superintend-
ent, No. 2 Coke Plant, Inland Steel Co.,
East Chicago, Ind.

Samelson, Lincoln R., president, Lake Pub-
lishing Corp., Box 148, Libertyville, Ill.

Schaber, D. R., laboratory supervisor, Bow-
ser, Inc., Fort Wayne Mfg. Div., Fort
Wayne 2, Ind.

Troike, Harold L., lubrication engineer,
Automatic Electric Co., Box 16, Depart-
ment 90.5, Northlake, Ill. For mail:
11137 Boeger Ct., Westchester, Ill.

Vercocck, Andrew C., chief engineer, pole
line hardware, Hubbard and Co., Box 61,
Lyons, Ill.

Warren, Carlyle F., supervisor, bar, plate
and shape products quality control,
Inland Steel Co., 30 W. Monroe St.,
Chicago, Ill.

Warwaruk, Joseph, instructor, University of
Illinois, 214 Talbot Laboratory, Urbana,
Ill. [A]

Weisberg, Alfred M., vice-president, Technic,
Inc., Box 965, Providence 1, R. I. For
mail: 7001 N. Clark St., Chicago 26, Ill.

Wells, James G., Jr., engineering manager,
Elgin MetalFormers Corp., 630 Congdon
Ave., Elgin, Ill.

Wolf, Fred, Touchdown Div., Redson-Rice
Corp., 1111 W. Winona Ave., Chicago
40, Ill.

Wolf, Thomas F., civil engineer I, Milwaukee
Sewerage Commission, Box 2079, Mil-
waukee 1, Wis. For mail: 4939 N. 61st St.,
Milwaukee 18, Wis. [A]

Yonker, Norris G., chief metallurgist, Thor
Power Tool Co., 175 N. State, Aurora, Ill.

Yoran, Calvin S., technical director, Dryden
Rubber Div., Sheller Mfg. Corp., Keokuk,
Iowa. For mail: R.R. 2, Keokuk, Iowa.

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St., Toledo 13, Ohio.

Blamire, W. P., assistant director, Technical
Research and Development, Packaging
Corporation of America, 415 E. Fulton
St., Grand Rapids 3, Mich.

Carlson, Carl Victor, chief engineer, Taylor &
Gaskin, Inc., 2210 Park Ave., Detroit 1,
Mich.

Eagle, Clayton W., senior buyer, Trim Ma-
terials Department Purchasing, Ford
Motor Co., Box 628, Dearborn, Mich.

Gierow, Albert O., chief engineer, George E.
Snyder Associates, 1318 Wildwood, Jack-
son, Mich. For mail: 2240 Maple Dr.,
Jackson, Mich.

Hergenroether, R. E., production manager,
Pillsbury Chemicals, 14066 Stansbury,
Detroit 27, Mich. For mail: 31072
Windsor, Garden City, Mich.

Johnson, F. Martin, 526 Clinton St., Grand
Haven, Mich. [A]

McCarthy, Gary P., civil engineer, United
Associates, Inc., Cheboygan, Mich. [A]

Saxer, Edwin Louis, professor of civil
engineering, University of Toledo, Toledo,
Ohio.

Smitley, M. L., assistant chief engineer,
Holley Carburetor Co., 11955 E. Nine
Mile Rd., Warren, Mich.

New England District

Berkshire Hathaway, Inc., Ken V. Chace,
supervisor of laboratory, Box 904, New
Bedford, Mass.

Carter's Ink Co., William E. Grady, man-
ager, quality control, 239 First St.,
Cambridge 42, Mass.

Trancoa Chemical Corp., A. S. Cummin,
general manager, Plastics Div., 312 Ash
St., Reading, Mass.

(Continued on p. 93)

* [A] denotes Associate Member.
† [S] denotes Sustaining Member.

NEW MEMBERS

(Continued from p. 92)

Bongiorno, Anthony John, structural designer, Linenthal & Becker, 16 Lincoln St., Boston, Mass. For mail: 465 Summer St., Lynnfield Centre, Mass. [A]

Carlisle, Duane F., chief engineer, Anchor Mfg. Co., Box 959, Manchester, N. H.

Delott, Charles R., engineer, Sprague Electric Co., North Adams, Mass. For mail: 30 Dover St., North Adams, Mass. [A]

Fisher, Richard G., ceramic engineer, Sprague Electric Co., North Adams, Mass. For mail: Water St., Williamstown, Mass. [A]

Gennone, Richard J., chief metallurgist, Texas Instruments, Inc., M & C Nuclear Div., Box 898, Attleboro, Mass.

Ingham, William, metallurgist, Tubular Rivet and Steel Co., Wollaston 70, Mass.

Johnson, Malcolm T., engineer, Electric Boat Div., General Dynamics Corp., Groton, Conn.

Litt, Jacob T., filter development engineer, Commercial Filters Corp., 2 Main St., Melrose 76, Mass. For mail: 61 Selkirk Rd., Brookline 46, Mass. [A]

McTague, Robert F., technical director, The Stanley Chemical Co., East Berlin, Conn.

Miller, Robert, supervisor, physical testing, A. G. Spalding and Bros., Inc. Chicopee, Mass.

Moissonnier, Raymond A., quality control engineer, Duesberg-Bosson Woolen Spinning Co., Box 70, Jefferson, Mass. [A]

Nardone, Donald Richard, civil engineer, 9 George Dr., Old Saybrook, Conn. [A]

Pitchon, Raphael, quality control director, Ansonia Mills, Inc., East Taunton, Mass.

Sheridan, W. J., manager, Everett Refinery, Esso Standard, Division of Humble Oil and Refinery Co., 30 Beacham St., Everett 49, Mass.

Toomey, Richard A., materials and process specification engineer, Raytheon Co., Missile Systems Div., Bedford, Mass.

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Whitehouse, John B., mechanical engineer, Department 514, Arthur D. Little, Inc., 20 Acorn Park, Cambridge 42, Mass. For mail: 9 Stonebridge Rd., Cochituate, Mass.

New York District

Albohn, Arthur R., research supervisor, Rayonier, Inc., Eastern Research Div., Whippany, N. J.

Blumenstock, Joan, chemist, Colgate Palmolive Co., 105 Hudson St., Jersey City, N. J. For mail: 604 Seventh Ave., Asbury Park, N. J. [A]

Chard, John E., head, Mechanical Test Section, The International Nickel Co., Inc., INCO Research Laboratory, Box U, Bergen Point Station, Bayonne, N. J.

Clausi, Joseph C., director, quality control, Mittag Div., Burroughs Corp., 76 Park Ave., Park Ridge, N. J.

Curgan, Mark N., technical director, Borne Chemical Co., Inc., Box 256, Elizabeth, N. J.

Dietrick, C. R., project engineer, Suburban Propane Gas Corp., Box 206, Whippany, N. J.

Edelman, J. A., manager, Styro Sales Co., 25-34, 50th Ave., Long Island City 1, N. Y. For mail: 114 Highridge Rd., New Rochelle, N. Y.

Flynn, Robert, chemist, Broadway Maintenance Corp., 22-09 Bridge Plaza N., Long Island City 1, N. Y. For mail: 45-17 45th St., Long Island City 4, N. Y. [A]

Forman, Benjamin G., consultant, 260 Bayview Ave., Massapequa, N. Y.

Frybergh, Francis L., chief of specifications, Skidmore, Owings & Merrill, Architects, 425 Park Ave., New York 22, N. Y.

Gaylord, Norman G., vice-president, research and development, The Western Petrochemical Corp., Polymer Div., 96 Roanoke Ave., Newark 5, N. J.

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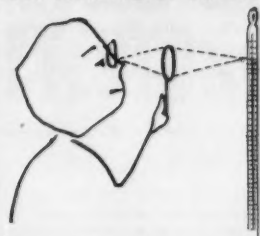
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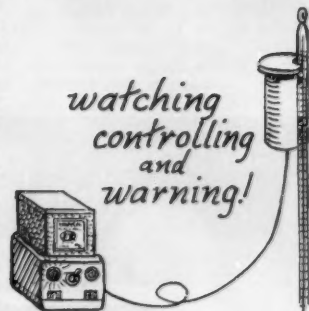
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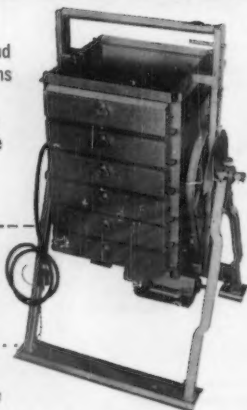


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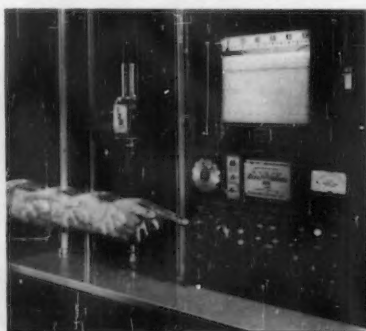
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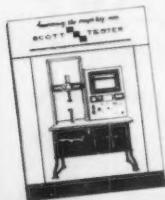
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- Herstein, Karl M.**, president, Herstein Laboratories, Inc., 44 New St., New York 4, N. Y.
- Israel, Milton W.**, vice-president, Victor Gloves, Inc., 49 E. 21st St., New York 10, N. Y.
- Jacobs, Fred F.**, technical service, Putnam Chemical Corp., Beacon, N. Y.
- Kendall, David N.**, director of research, Kendall Infrared Laboratories, 1030 Sherman Ave., Plainfield, N. J.
- Kihlgren, T. E.**, Development and Research Div., The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.
- Landon, Robert B.**, director of research and engineering, Revere Corporation of America, 845 N. Colony Rd., Wallingford, Conn.
- Lang, Eugene M.**, president, Resources and Facilities Corp., 60 E. 42nd St., New York 17, N. Y.
- Levendusky, Joseph A.**, group leader, research and development, Graver Water Conditioning Co. Div., Union Tank Car Co., 116 W. 14th St., New York 11, N. Y.
- Masseti, P. A.**, managing director, Public Service Testing Laboratories, Inc., 137 E. 25th St., New York 10, N. Y.
- Mims, Norman**, chemist, Technical Dept., Imperial Chemical Industries (New York), Ltd., 488 Madison Ave., New York 22, N. Y.
- Ochek, George C.**, chemist, Box 540, R.D. 4, New Brunswick, N. J.
- O'Reilly, Joseph**, sales service manager, American Mineral Spirits Co., Mountain Ave., Murray Hill, N. J.
- Paris, Lyle B.**, general manager, Eastern Div., A. C. Horn Cos., Division of Sun Chemical Corp., 2133 85th St., North Bergen, N. J. For mail: 87 Plymouth Rd., Hillsdale, N. J.
- Proctor, P. B.**, staff manager, quality control, Johns-Manville Corp., 22 E. 40th St., New York 16, N. Y.
- Range, Walter K., Jr.**, product research, Esso Research and Engineering Co., Box 51, Linden, N. J. For mail: 384 Elmora Ave., Elizabeth, N. J. [A]
- Simon, Jay**, chemical engineer, Burndy Corp., Richards Ave., Norwalk, Conn. For mail: 33 E. Grand St., Mt. Vernon, N. Y. [A]
- Smoluk, George R.**, engineering editor, Bre-skin Publications, 575 Madison Ave., New York 22, N. Y.
- Stahl, R. F.**, assistant manager, manufacturing economics, American Oil Co., 555 Fifth Ave., New York 17, N. Y.
- Sulkes, Martin**, development engineer, U. S. Electric Manufacturing Co., 222 W. 14th St., New York, N. Y. For mail: 34-15 Parsons Blvd., Flushing 54, N. Y. [A]
- Thelin, Jack H.**, group leader, rubber chemical research, American Cyanamid Co., Bound Brook, N. J.
- Treibitz, Irwin**, chemical sales engineer trainee, Pfaudler Permutit, Inc., 50 W. 44th St., New York 36, N. Y. For mail: 86-17 Shore Pkwy., Howard Beach 14, N. Y. [A]
- Vroom, William Lee**, engineer, Electronics, Inc., 127 Sussex Ave., Newark 3, N. J. [A]
- Walker, Lancelot H.**, Development and Research Div., The International Nickel Co., Inc., 67 Wall St., New York 23, N. Y.
- Wilcox, E. D.**, manager, product technology, International Business Machines Corp., IBM South Rd., Department 887, Poughkeepsie, N. Y.
- Zambrow, J. L.**, director of engineering, Syl-vania Corning Nuclear Corp., 208-20 Willets Point Blvd., Bayside, L. I., N. Y.

Northern California District

- Aerojet General Corp.**, T. C. Yao, supervisor, Analytical Development Section, Solid Rocket Plant, Box 1947, Sacramento, Calif.
- Beveridge, Colin M.**, 1458 88th Ave., Oakland 21, Calif. [A]

(Continued on p. 96)

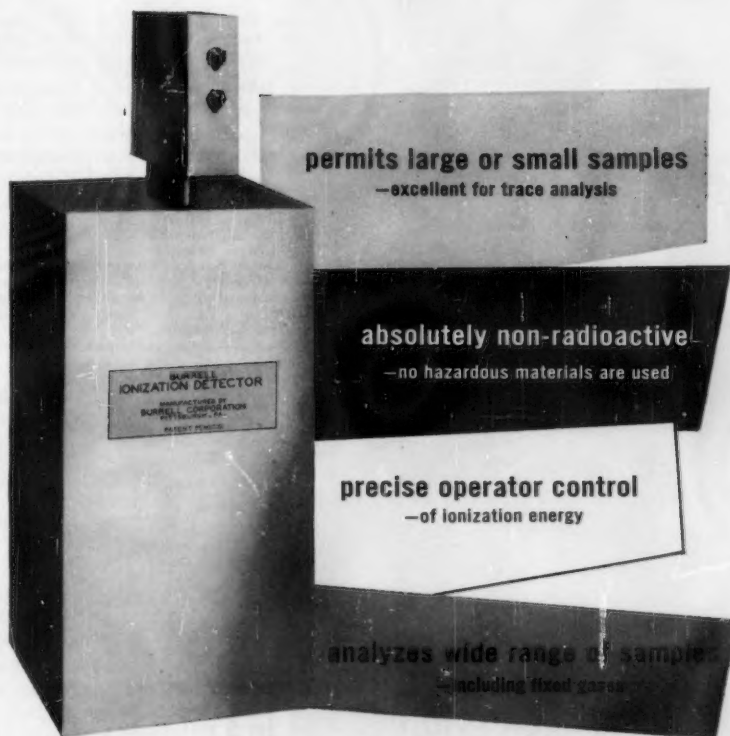
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- Clapper, Robert B.**, structures engineer, Lockheed Missiles and Space Div., Lockheed Aircraft Corp., Dept. 70-81, Bldg. 102, Sunnyvale, Calif.
- Dost, William A.**, research director, California Redwood Assn., 576 Sacramento St., San Francisco 11, Calif.
- Douglas, Bruce M.**, civil engineer, Jordan, Paquette & Maurer, 492 W. San Carlos St., San Jose, Calif. For mail: 174 Asbury St., San Jose, Calif. [A]
- Gruenewald, Richard B.**, quality control analyst, Shockley Transistor Corp., 1117 California St., Palo Alto, Calif.
- Jones, F. Norman**, chief chemist, Pacific Cement and Aggregates, Inc., Davenport, Calif.
- Leiser, Craig Frederick**, ceramicist-metallurgist, General Electric Co., Vallecitos Atomic Lab., Box 846, Pleasanton, Calif. For mail: 601 Sorenson Rd., Apt. 16, Hayward, Calif. [A]
- Reynolds, Kenneth B.**, chemical engineer, Kennedy Engineers, 604 Mission St., San Francisco 5, Calif.
- Rapp, Howard C.**, manager of development, Raychem Corp., 2821 Fair Oaks, Redwood City, Calif.
- Ruth, Leo W., Jr.**, partner, Ruth & Going, 919 The Alameda, San Jose 26, Calif.

Philadelphia District

- Spring City Knitting Co.**, Franz Hausner, director of quality control, Spring City, Pa.
- Clupper, Donald L.**, material engineer, Ingersoll-Rand Co., 101 N. Main St., Athens, Pa.
- Hersh, Marvin**, senior research associate,

- Wyeth Laboratories, Inc., Box 8299, Philadelphia 1, Pa.
- Mahoney, James**, Mechanical Research Section, Applied Science Corporation of Princeton, A Division of Electro-Mechanical Research, Inc., Box 44, Princeton, N. J.
- Millaway, Nelson Robert**, supervisor, materials testing, (textiles), International Latex Corp., Playtex Park, Dover, Del.
- Orser, Philip H.**, dyeing and research, Frankford Woolen Mills, Inc., Wister St. and Godfrey Ave., Philadelphia 38, Pa.
- Pardee, Eliot H.**, manager, Research and Development Laboratory, Nassau Research and Development Co., Inc., 308 Madison St., Riverside, N. J. For mail: 211-D Haddon Hills, Haddonfield, N. J. [A]
- Pocalyko, Andrew**, staff metallurgist, Aero-projects, Inc., 310 E. Rosedale Ave., West Chester, Pa.
- Rimrott, Ulrich A.**, senior research engineer, SKF Industries, Inc., Front and Erie, Philadelphia 32, Pa. For mail: 4614 Newhall St., Philadelphia 44, Pa.
- Trentsch, Robert C.**, assistant sales manager, Tiona Petroleum Co., Box 945, E. Camden Station, Camden, N. J.
- Vurpillat, R. J., Jr.**, branch manager, Pittsburgh Testing Laboratory, 1330 Locust St., Pittsburgh 19, Pa. For mail: 3120 S. 20th St., Philadelphia 45, Pa.
- Yerkes, John B.**, owner, Yerkes Engineering Co., 101 Charles Dr., Bryn Mawr, Pa.

Pittsburgh District

- Keystone Alloys Co.**, James P. Ebersberger, research director, Box 308, Derry, Pa.
- McCreary Tire and Rubber Co.**, L. M. Longworth, development manager, Box 700, Indiana, Pa.
- Coburn, S. K.**, research technologist, U. S. Steel Corp., Monroeville, Pa.
- Fields, Davis S., Jr.**, research metallurgist, Alcoa Research Laboratories, Aluminum Company of America, Box 772, New Kensington, Pa. For mail: 2617 Paige St., New Kensington, Pa.

- Heiser, Victor F.**, specification engineer, National Tube Div., U. S. Steel Corp., 415 Fourth Ave., McKeesport, Pa.
- Jackson, R. W.**, director of research, Pittsburgh Piping and Equipment Co., 158 49th St., Pittsburgh 1, Pa.
- Johnson, A. F.**, works engineer, Walworth Co., Huff Ave., South Greensburg, Pa.
- Mannella, W. J.**, manager, quality control, Johnson Bronze Co., South Mill St., New Castle, Pa.
- Nobel, Sanford M.**, 212 Barth Ave., Pittsburgh 28, Pa. [A]
- Schroeder, Fred W.**, director of research, North American Refractories Co., Curwensville, Pa.
- Tash, J. A.**, engineer, Shippingport Atomic Power Station, Duesquesne Light Co., Shippingport, Pa.
- Wickett, John Allen**, project manager, Refractories Div., H. K. Porter Co., Inc., Porter Bldg., Pittsburgh 19, Pa.

Rocky Mountain District

- Bermudez, Jack**, civil engineer, U. S. Forest Service, Holbrook, Ariz. For mail: 2402 Edna Ave., N. W., Albuquerque, N. Mex. [A]
- Jordan, John T.**, professional engineer, P. O. Drawer 69, Kingman, Ariz.
- Rivard, Joseph B.**, staff member, Sandia Corp., Sandia Base, Albuquerque, N. Mex. For mail: 2900 Garcia, N. E., Albuquerque, N. Mex. [A]
- Schultz, Leo C.**, executive director, Colorado State Bureau for Lathing and Plastering, Inc., 509 Interstate Trust Bldg., 1130 16th St., Denver 2, Colo.
- Scott, Barbara J.**, testing materials technician, Materials Testing Div., Wyoming Highway Dept., Cheyenne, Wyo. For mail: 3937 McComb, Cheyenne, Wyo. [A]
- Ungnade, Herbert E.**, staff member, GMX-2, Los Alamos Scientific Laboratory, Box 1663, Los Alamos, N. Mex.
- Vesper, Russell L.**, assistant forest engineer, U. S. Forest Service, Box 61, Santa Fe, N. Mex. For mail: 120 W. Santa Fe Ave., Apt. G, Santa Fe, N. Mex. [A]
- Wanggard, Lew A.**, project engineer, Nielsen, Reeve & Maxwell, Inc., 275 E. 4425 S., Washington Terrace, Utah. [A]
- White, Ken R.**, principal, Ken R. White, consulting engineers, Inc., 1507 Marion St., Denver 18, Colo.
- Witter, Robert V.**, chemist, Husky Hi-Power, Inc., Cody, Wyo.

St. Louis District

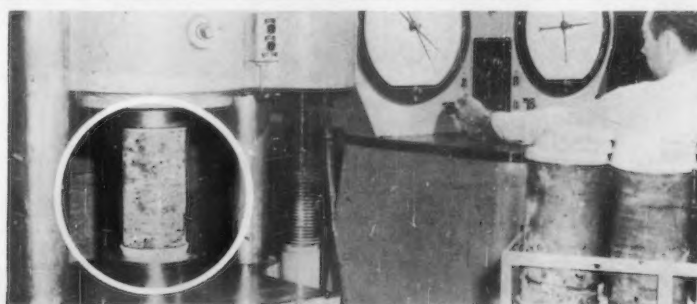
- Angold, J. A.**, engineer of tests, Atchison, Topeka & Santa Fe Railway Co., Motive Power Bldg., Topeka, Kans.
- Fanning, Paul Harold**, chief engineer, John A. Denie's Sons Co., 373 Adams Ave., Memphis, Tenn.
- Farmer, Dwight W.**, quality control manager, The Greenleaf Manufacturing Div., Mandrel Industries, Inc., 7814 Maplewood Industrial Court, St. Louis 17, Mo.
- Fellows, John A.**, assistant technical director, Mallinckrodt Chemical Works, Box 472, St. Charles Mo.
- Johnson, Newell**, manager, St. Louis District, Robert W. Hunt Co., 2008 Olive St., St. Louis 3, Mo.
- Patterson, Lowell Ray**, chief metallurgist, Gardner-Denver Co., Quincy, Ill.
- Thornburg, Robert W.**, director of engineering, Blaw-Knox Co., Mattoon, Ill.
- Woods, Robert Earl**, Indiana State Highway Dept., 102 N. Senate, Indianapolis, Ind. For mail: 1206 Parrish St., Mt. Carmel, Ill. [A]

Southeast District

- Alfred, Robert Charles**, chief engineer, Campbell Limestone Co., Liberty, S. C.
- Amminger, Otilie**, associate professor of metallurgy, University of South Carolina, Department of Mechanical Engineering, 745 Sumter St., Columbia, S. C.
- Ashley, George H.**, technical superintendent, McCormick Mills, McCormick, S. C.
- Finch, Cabell B.**, staff member, Oak Ridge National Laboratory, Union Carbide Nuclear Co., Oak Ridge, Tenn. For mail: Box 2117, Oak Ridge, Tenn. [A]
- Gavens, Frank**, stylist designer, Columbus

(Continued on p. 100)

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CIRCLE 557 ON READER SERVICE CARD

DF9-8A

THESE NEW B-L-H GAGES

SIMPLIFY STRAIN MEASUREMENT

Since its initial development, some 20 years ago, the SR-4 Bonded Filament Strain Gage has simplified the approach to countless structural analysis and design problems, many of which would otherwise have been immensely difficult, if not impossible, to solve accurately.

Through the years literally hundreds of SR-4 gage types and configurations have been produced, each designed to solve a particular strain measurement problem as easily and precisely as possible.

Now, four new additions to the B-L-H strain gage family make possible still greater simplification of a variety of stress analysis jobs. One of them may be the answer to your problem.

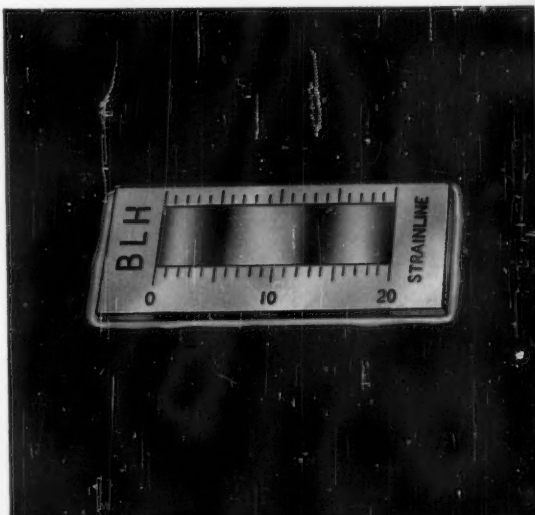
STRAINLINE PHOTOELASTIC STRAIN GAGE

For the researcher or engineer who would like direct indication of strain, without resorting to electronic instrumentation, time-consuming connections, etc., the new Strainline photoelastic strain gage is an ideal solution.

Small, rugged, very simple to install and use, Strainline gages provide immediate, visual indication of strain magnitude. Each gage displays a series of visible transverse interference lines. When it is bonded to a surface undergoing strain, these lines are displaced along the length of the gage. The magnitude of displacement, with respect to a fixed scale on the gage mask, is directly proportional to the strain.

Unlike other photoelastic devices, the Strainline gage has negligible transverse sensitivity . . . no correction of readings is necessary. Its fringe lines are sharper and easier to read accurately (to better than 50 microinches per inch) in either natural or artificial light.

Strainline gages are available with gage lengths of $\frac{3}{4}$ " and 2". For more information ask for Product Data 4325.



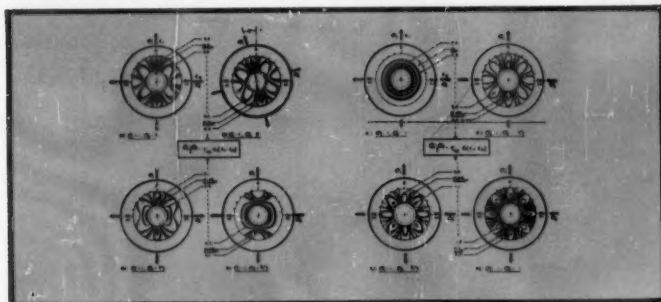
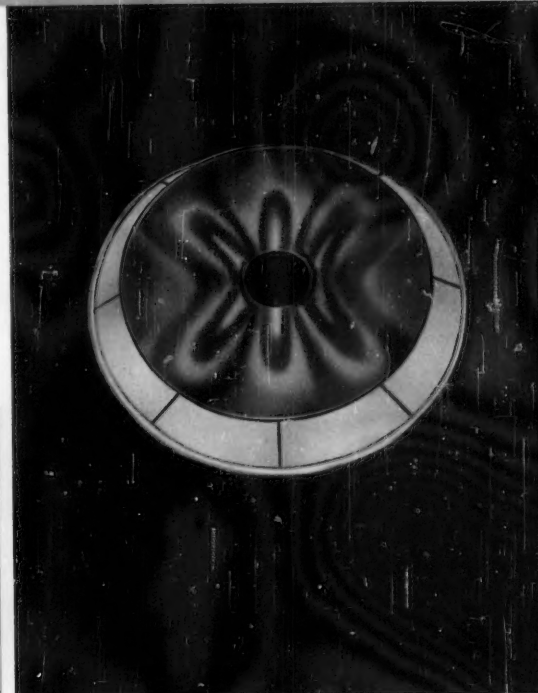
STRAINLINE PHOTOELASTIC STRAIN COMPASS

A natural companion to the Strainline gage is the Strainline compass. A truly unique photoelastic device, this small, circular gage provides quick visual indication of strain direction.

When a surface to which it is bonded undergoes strain, a symmetrical pattern of interference fringes appears on the face of the gage. The axes of symmetry of this pattern provide clear, immediate indication of the directions of principal strain.

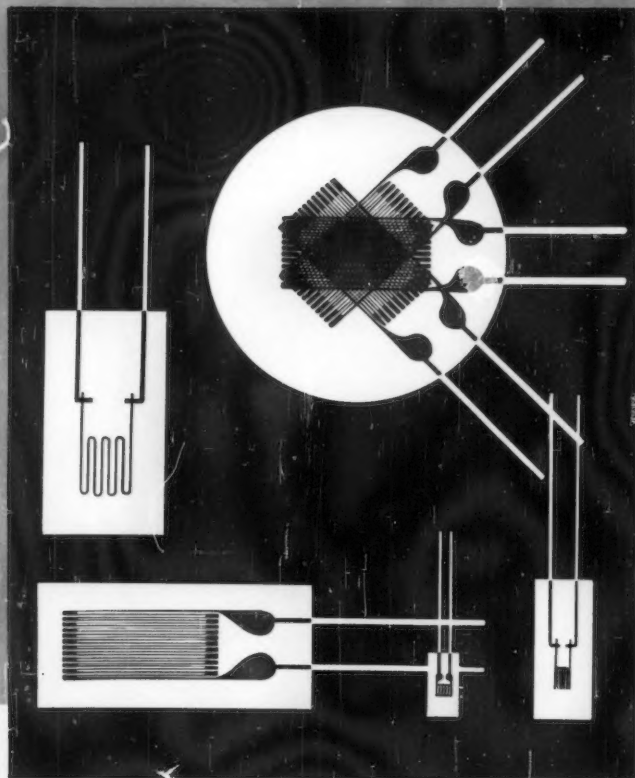
A number of Strainline compasses, bonded to a test area may be photographed or observed simultaneously to determine localized strain direction over the entire area at any given instant.

Strainline compasses are available with diameters of $\frac{3}{8}$ " and 1". For more information ask for Product Data 4326.



Theoretical shearing stress distribution for different stress ratios.

MORE NEW SR-4® STRAIN GAGES ON NEXT PAGE



SR-4® SELECTED MELT SELF-TEMPERATURE-COMPENSATED STRAIN GAGES

Probably the easiest way to compensate for temperature effects on strain gage readings is to use a gage which is "matched" to the material of the surface under test.

A new and complete line of these matched, or "Selected-Melt," gages of both wire and foil grid construction is now available from B-L-H for use on a variety of materials. Produced from alloy batches or "melts" which have been carefully selected to exhibit certain predetermined thermal coefficient of resistance characteristics, these gages produce apparent strains of no more than $\pm 1 \mu\text{in}/\text{in}/^\circ\text{F}$ over the range of from 50 to 250°F. Most of the commonly-used SR-4® wire and foil strain gage types are now available with Selected-Melt grids. Three characteristic melts are offered for each gage type, making Selected-Melt strain gages applicable to materials having thermal expansion coefficients of 6 (e. g., mild steel), 9 (stainless), and 13 (aluminum) parts (± 1 part) per million per °F.

Melts are also available on special order for materials having other coefficients.

Ask your SR-4® Strain Gage representative how new "Selected-Melt" gages can fit into your testing problem. For more information ask for Product Data 4313.

SR-4® UNIVERSALLY-TEMPERATURE-COMPENSATED STRAIN GAGES

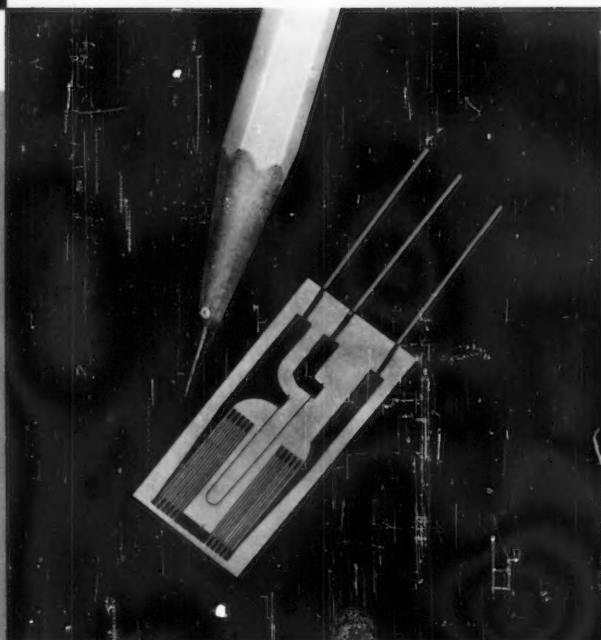
Although it serves a useful and important function, each self-temperature-compensated strain gage is necessarily restricted in use to the specific material for which it is intended and over a limited temperature range.

The new universally-temperature-compensated gage, however, may be used with a high degree of accuracy on almost any material. In addition, it will provide compensation over an extremely wide temperature range.

The temperature response characteristics of this remarkable new gage can be changed by varying the parameters of a simple external circuit. Two models are available, each with a gage length of $\frac{1}{2}$ ". Type FNB-50-12E, on a phenolic base, is recommended for use from -320°F to +500°F.

Type FNH-50-12E, on a strippable vinyl base, may be used from -320°F to +850°F.

For more information ask for Product Data 4321.



AT YOUR DOORSTEP . . . The world's most complete strain gage line.

All Baldwin-Lima-Hamilton SR-4® Strain Gages, instruments and accessories are now carried in stock for immediate delivery at 15 strategic points throughout the country. Write for the address of the BLH Sales-Engineering Representative nearest you.

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Electronics & Instrumentation Division
Waltham, Mass.



KREBS CONSTANT TEMPERATURE BATHS

K 1997

FOR USE WITH CAPILLARY VISCOMETERS

A.S.T.M. D 445-53 T



Patent No. 2,227,938

A highly sensitive apparatus to hold constant temperature in all parts of the bath within $\pm 0.02^\circ \text{F.}$, or better over the entire temperature range, from below room temperature up to 210°F. , with water as the bath medium.

Bath proper is of the same construction as the Mid-Century Model except that it has a separate control box that houses the Sealed Electronic Relay, Variable Transformer, Etc. The heavy bronze chrome polished bath top and the shielded chromeplated tubular heaters, cooling coil and circulating tube are one unit and can be lifted out for inspection or cleaning without causing any disarrangement.

Supplied as illustrated with six receptacles for Modified Ostwald or Ubbelohde Viscometers. Vapor type regulator is furnished with the apparatus but any sealed sensitive regulator can be used as the relay draws only a few micro amperes.

The K 1997A BATH is of the same construction but has a large semi-circular opening in the top-plate for which cover plates of different openings are available for general purpose work and has 2 studs mounted in the front on which articles can be clamped to suspend in the bath.

115 Volts, 50 or 60 Cycle. Other circuits can be furnished on request.

Net Weight: 58 lbs. Shipping Weight for Domestic shipments 95 lbs.

The heavy bronze chrome polished bath top and the circulating system which contains the shielded chromeplated tubular heaters is one unit and can be lifted out for inspection or cleaning without causing any disarrangement. Insert plates with openings to suit the receptacles of different types of viscosity tubes, racks for thermometer testing or special openings for general purpose work are placed in the large semi-circular recessed bath top opening. 2 Studs are mounted on front of top-plate on which articles can be clamped to suspend in the bath.

Elevation brackets for the Pyrex jar are available when bath is to be used for Reverse Flow Viscosity Tests.

Dimensions: Housing 17 inches wide, 18 inches deep, 13 inches high. The total height to top of motor when bath is completely assembled as illustrated is 19 1/2 inches.

Net Weight: 110 lbs. Shipping Weight for Domestic shipments 165 lbs.

Supplied as illustrated for 115 Volts, 50 or 60 Cycle. Other circuits can be furnished on request.

MID-CENTURY MODEL

FOR USE WITH CAPILLARY VISCOMETERS

A.S.T.M. D 445-53 T

STANDARDIZING THERMOMETERS

A.S.T.M. E 77-56 T

FOR ANALYTICAL AND RESEARCH WORK



Patent No. 2,227,938

A Constant Temperature Bath of Ultra Precision performance of $\pm 0.01^\circ \text{F.}$ or better with Vernier Control and actuated by a Quickset mercury in glass magnetic adjustment thermoregulator. Accurate temperature and positive heat distribution to all parts of the bath are obtained and maintained by the Unique assembly of cooling and heating coils in the circulating tube that delivers the pre-heated bath liquid of the proper operating temperature throughout the entire bath and not depending on agitation of the bath liquid.

The low temperature bath will operate from below room temperature up to 210°F. , with water as the bath medium. It is also available for temperatures up to 400°F. , using oil for bath liquid.

The combination Moat and Control Box that houses the Sealed Electronic Relay and variable transformers is of sturdy construction, with heavy cast aluminum base and welded steel inner frame. The panels and base are instrument gray wrinkle finished and held in place by stainless steel corner trimmings. The front and rear panels are readily removable for inspection of controls. The stainless steel top is beveled around the opening to take care of any spillage. Leveling screws in front of base and an adjustable fluorescent light is mounted at the rear of Pyrex jar.

The Moat has a removable safety container of sufficient capacity to hold the bath liquid should the Pyrex jar accidentally break and in addition is provided with a drain pipe to which a hose can be attached to lead into a drain or can.

KREBS ELEC. & MFG. CO., INC.



237-239 Lafayette St., N.Y. 12, N.Y.

FOR FURTHER INFORMATION CIRCLE 559 ON READER SERVICE CARD

NEW MEMBERS

(Continued from p. 96)

Fibre Mills Co., Columbus, Ga. For mail: 4814 21st Ave., Columbus, Ga.
Hafford, Joseph A., research engineer, Orr Industries Co., Division of Ampex Corp., Shamrock Circle, Opelika, Ala.
Knuckey, Norman E., vice-president, Gulf Coast Testing Laboratory, Inc., 6500 49th St., N., Pinellas Park, Fla. [A]
McCoy, Russell A., Jr., engineer, The Harwood Beebe Co., Box 2505, Station A, Spartanburg, S. C.
Tyson, James A., Construction Dept., Alabama Power Co., 600 N. 18th St., Birmingham 2, Ala.

Southern California District

Becker, Earl Ray, junior civil engineer, Department of Water Resources, 215 E. Broadway, Glendale, Calif. For mail: 3425 Mayfield Ave., LaCrescenta, Calif. [A]
Belkows, John C., general superintendent, Joslyn Pacific Co., 5100 District Blvd., Los Angeles 58, Calif.
Bertie, J. Sigmund, chief process engineer, Norris Thermador Corp., 5215 S. Boyle Ave., Los Angeles 58, Calif.
Bush, C. A., director, quality control, Parker Aircraft Co., 5827 W. Century Blvd., Los Angeles 45, Calif.
Hilberg, Herman C., field engineer, Pacific Scientific Co., Box 22019, Los Angeles 22, Calif.
Kim, Young Chun, civil engineer, Daniel, Mann, Johnson, & Mendenhall, 3325 Wilshire Blvd., Los Angeles 5, Calif. For mail: 5229 Palm Dr., La Canada, Calif. [A]
Martin, George, chief metallurgist, Honolulu Oil Co., Industrial Research Laboratory Div., 961 E. Slauson Ave., Los Angeles 11, Calif.
McKinley, Laton D., night toolroom foreman, Modern Faucet Manufacturing Co., 1700 E. 58th Pl., Los Angeles 1, Calif. For mail: 6347 "D" Middleton St., Huntingdon Park, Calif.

Muller, Paul J., chemist, Laboratory Div., Standard Oil Company of California, El Segundo, Calif. For mail: 4910 Vista-deoro Ave., Los Angeles 43, Calif.
Nelson, Rodney W., department head, material and process, Grayson Controls Div., Robertshaw-Fulton Controls Co., Long Beach Blvd. at Long Beach Freeway, Long Beach 5, Calif.
Ricchio, Sam G., laboratory technician, research, Tretolite Company of California, 5515 Telegraph Rd., Los Angeles 22, Calif. [A]
Smith, George F., chief structural engineer, Koebig & Koebig, 3242 W. Eighth St., Los Angeles 6, Calif. For mail: 5156 Townsend Ave., Los Angeles 41, Calif.
Young, Tom L., research and development chemist, Atomics International, Canoga Park, Calif. For mail: 6516 Woodley Ave., Van Nuys, Calif. [A]

Southwest District

Appel, Richard D., 2nd Lieutenant, U. S. Department of the Army, Fort Hood, Tex. For mail: 614 Sutton Dr., Killeen, Tex. [A]
Britain, Kenneth Edward, chief engineer, Midwestern Gas Transmission Co., A Subsidiary of Tennessee Gas Transmission Co., Houston, Tex. For mail: Box 599, Houston 1, Tex.
Corpus Christi, City of, Public Works Dept., Jack M. Graham, director of public works, City Hall, Box 1622, Corpus Christi, Tex.
Fry, Mark W., plant engineer, Dierks Forests, Inc., Box 387, DeQueen, Ark. [A]
Hester, C. Doyce, plant laboratory director, Reynolds Metals Co., Box 109, Corpus Christi, Tex.
Hillis, Hugh W., assistant manager, Sun Terminal, Sun Oil Co., Box 2831, Beaumont, Tex.
Iddings, Frank A., research chemist, Esso Standard, A Division of Humble Oil and Refining Co., Box 551, Baton Rouge 1, La. For mail: 1365 Harco Dr., Baton Rouge 6, La. [A]
Speer, J. Ramsey, III, technical services administrator, Tuboscope Co., Box 808, Houston 1, Tex.

Williams, Larry E., engineer, Cities Service Oil Co., Bartlesville, Okla. [A]

Washington (D. C.) District

American Viscose Corp., Film Div., A. W. Hogeland, Fredericksburg, Va.
American Viscose Corp., Film Div., H. E. Stevens, Fredericksburg, Va.
Steinthal and Co., Inc., M. Paul Patterson, chief, quality control, c/o Roxboro Mfg. Co., Madison Ave., Roxboro, N. C.
Anderson, Harry G., Jr., research associate, National Bureau of Standards, Room 307, Bldg. 6, Washington 25, D. C.
Campbell, James L., partner, Fisher, Nes, Campbell and Associates, 2120 N. Charles St., Baltimore 18, Md.
Craig, Neuman R., Jr., chemist, U. S. Department of Agriculture, Naval Stores Branch, Tobacco Div., Agricultural Marketing Service, 2141 S. Agriculture Bldg., Washington 25, D. C.
Hale, W. N., assistant manager, Munsell Color Co., Inc., 2441 N. Calvert St., Baltimore 18, Md.
Jacobus, R. W., manager, operations and engineering, Virginia Steel Co., Inc., Box 7146, Richmond 21, Va.
Joslin, R. E., manager, Preparation Dept., Clinchfield Coal Co., Dante, Va.
Riba, Lofar F., assistant director of promotion and engineer, Structural Clay Products Inst., Region 3, Philadelphia Pa. For mail: 2301 N. Charles, Room 303, Baltimore 18, Md. [A]
Ryan, James V., physicist, National Bureau of Standards, 3712 Industrial Bldg., Washington 25, D. C.
Young, W. L., chief engineer, Norfolk & Western Railway Co., Engineering Dept., Roanoke, Va.

Western New York-Ontario District

Adair, J. Howard, assistant director, Ontario Research Foundation, 43 Queen's Park, Toronto 5, Ont., Canada.
Blakeley, J., chief engineer, Victaulic Co. of Canada, Ltd., Box 400, Station T, Toronto 19, Ont., Canada.

(Continued on p. 101)

THE VICATESTER

The Vicateter, a Plastisol Cure Tester fills the need for an easily applied instrumental method of evaluating the penetration hardness and resiliencies of polymeric materials, providing readings that can be directly translated into terms which describe the penetration hardness and natural resiliency of the particular material being tested.

The Vicateter measures the degree of elastic recovery exhibited when the driving load is removed from the penetration needle. Available adjustments permit testing samples of varying initial thicknesses and shapes, giving chart readings for needle motion as slight as 0.7 mils, or as much as 125 mils.

Bulletin M-5914 is available giving more complete information



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NEW MEMBERS

(Continued from p. 100)

- Brighty, R. H., chief engineer, Renfrew Electric, IRC Div., 349 Carlaw Ave., Toronto, Ont., Canada.
- London, W. P., consulting engineer, W. P. London and Partners, 1211 Drummond Rd., Niagara Falls, Ont., Canada.
- Richter, S. J., project engineer, Leland Electric Canada, Ltd., Guelph, Ont., Canada. [A]
- Schregel, Peter, Merritt-Chapman & Scott Corp., Lewiston, N. Y. For mail: 315 Benning Rd., West Falls, N. Y. [A]
- Sherren, W. D. L., product development manager, Herding Carpets, Ltd., Box 580, Brantford, Ont., Canada.
- Verna, David M., civil engineer, E. Muller Construction Co., 70 South Ave., Rochester, N. Y. For mail: 452 Linden Ave., Rochester 10, N. Y. [A]

Outside Established Districts

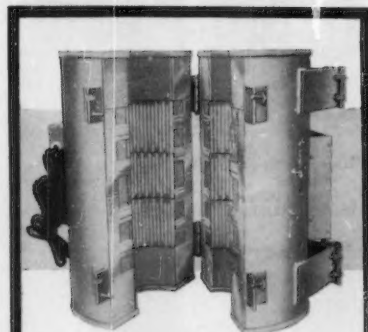
- Benjamin, Edwin D., partner, Thomas & Benjamin & Clayton, Box 783, Grand Island, Nebr.
- Borg, Ray A., contracts and specifications engineer, Omaha Public Power District, 403 Electric Bldg., Omaha 2, Nebr.
- Cassun, George W., Jr., junior civil engineer, California Department of Public Works, 430 Wabash Ave., Eureka, Calif. For mail: 1804 Montana Ave., Black Eagle, Mont. [A]
- Decker, Ray S., head, soil mechanics, U. S. Department of Agriculture, Soil Conservation Service, 800 J St., Lincoln, Nebr.
- Frashour, Ronald G., assistant manager, Pacqua, Inc., Box 78, Dillard, Ore.
- Hoyle, Robert J., Jr., assistant director of research, Potlatch Forests, Inc., Lewiston, Idaho.
- Idaho State Plumbing Board, T. E. Flood, executive office, Box 1731, Boise, Idaho.
- Liu, Paul S., materials engineer, Honolulu Construction and Draying Co., Ltd., Box 190, Honolulu 10, Hawaii.
- Olivieri-Cintrón, Elmer, engineer in charge, materials laboratory, University of Puerto Rico, College of Engineering, Agriculture and Mechanic Arts College, Mayaguez, Puerto Rico.
- Osterman, Richard, Northern Testing Laboratory, Box 1561, Great Falls, Mont. For mail: 1510 Montana Ave., Black Eagle, Mont. [A]
- Peters, Stanley L., engineer, Kingery Construction Co., 1941 Y St., Lincoln, Nebr. For mail: 3941 S. 20th, Lincoln, Nebr. [A]
- Price, Edward W., instructor, mechanical engineering, North Dakota State College, Fargo, N. Dak. For mail: 715 Fourth St., N. Fargo, N. Dak.
- Streeter, Daniel D., Jr., structures engineer, Allowables Unit, Boeing Airplane Co., Seattle, Wash. For mail: 2243 Viewmont Way, Seattle 99, Wash.
- Vendrell, J. R., Jr., engineer, Ponce Builders, Ponce, Puerto Rico. For mail: Box 1878, Ponce, Puerto Rico. [A]
- Western Electric Co., Inc., Manufacturing Div., L. A. Wengel, assistant superintendent, manufacturing engineering, Box 1400, Peony Park Station, Omaha 14, Nebr. [S]
- Williams, Harold Gene, assistant engineer, Ready-to-Pour Concrete Co., Box 1221, Idaho Falls, Idaho. [A]

Other Than U. S. Possessions

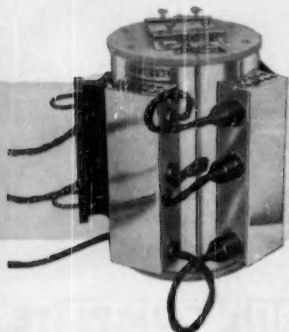
- Adelaide, University of, Barr Smith Library, W. A. Cowan, librarian, Adelaide, South Australia.
- British Tube Mills (Australia), Pty., Ltd., H. A. Goldie, chief metallurgist, Churchhill Rd., Kilburn, South Australia.
- Imperial Chemical Industries, Ltd., H.O.C. Div., Intelligence Section, Billingham, County Durham, England.
- Industrias Kaiser Argentina, S. A., O. V. Navarro, head, Vendor Engineering Dept., Paseo Colon 439, 5th Floor, Front, Buenos Aires, Argentina.

(Continued on p. 102)

HEVI-DUTY Tube Furnaces for Tensile and Creep Testing Machines



Split tube furnace has three zones of temperature control for operation to 2200° F. Heating chamber is 8" I.D. x 16" length with 4½" vestibules on each end that reduce heat losses and extend length of the uniform temperature zone.



Three zone, split tube, 2200° F. furnace has 2½" I.D. x 10" long heating chamber. Three built-in thermocouples provide easy temperature checks. Closing cover reduces stack effect, preventing loss of heat.



Solid tube furnace has 2½" I.D. x 18" long heating chamber, arranged in three zones of temperature control. A fused quartz window is set in the side of the furnace for viewing the specimen.

- Assure stable, uniform heat in multiple zones
- Temperature ranges to 1850, 2200 or 2600° F.

HEVI-DUTY vertical tube furnaces feature multiple zone heating which provides accurate control of temperatures and increases the length of the uniform temperature zone.

The heating chamber usually is divided into three or more zones of control. Precise temperature control is assured by the use of stepless variable transformers that regulate each heating zone. Troublesome, time-consuming adjustments of shunts are eliminated.

HEVI-DUTY vertical tube furnaces are available in three temperature ranges—1850, 2200 and 2600° F. The split tube design of these furnaces provides easy placement and handling of test specimens—an outstanding feature of HEVI-DUTY. Furnaces for 1850° F. and 2200° F. have "Multiple-Unit" heating coils that radiate heat directly into the chamber for fast temperature response. Silicon carbide rods are used in the 2600° F. furnaces.

HEVI-DUTY "zone-controlled" tube furnaces are available with complete control panels and all instrumentation. Several units are available from stock for immediate delivery. Others are built to meet specific requirements.

For more information write to HEVI-DUTY ELECTRIC CO., Milwaukee 1, Wisconsin.

WRITE FOR NEW BULLETIN!

Bulletin 559 gives details and complete description on HEVI-DUTY vertical tube furnaces. Write for your copy today!



HEVI-DUTY

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BASIC PRODUCTS CORPORATION

HEVI-DUTY ELECTRIC COMPANY, MILWAUKEE 1, WISCONSIN
Industrial Furnaces and Ovens, Electric and Fuel • Laboratory Furnaces • Dry Type Transformers • Constant Current Regulators
CIRCLE 561 ON READER SERVICE CARD

NEW MEMBERS

(Continued from p. 101)

Austin, Derek T., works technical superintendent, Aluminum Company of Canada, Ltd., Kingston, Ont., Canada.
 Bierstock, Donald A., sales engineer, Master Builders Co., Ltd., 1030 Pacific Ave., Winnipeg, Man., Canada. [A]
 Cady, Philip D., engineer, Lago Oil and Transport Co., Ltd., Aruba, Netherlands Antilles. For mail: Box 407, Seroe Colorado, Aruba, Netherlands Antilles. [A]
 Coletti, Jack A., president, American Consulting Corp., 211 Elm St., Clairton, Pa. For mail: Stahl and Walzwerke, Rasselstein-Andernach, Niewied, Germany.

Evans, R. Stuart, group leader, wood research, Rayonier Canada, Ltd., Research Div., 8809 Heather St., Vancouver 14, B. C., Canada.
 Fernandez, Vicente S., materials engineer, Gulf District, U. S. Army Corps of Engineers, Box 1606, Teheran, Iran.
 Flynn, John Patrick, construction technician, Raymond International Inc., 140 Cedar St., New York 6, N. Y. For mail: Raycon-16, Pitsanuloke, Thailand.
 Gogineni, Rayudu, c/o Motaparti Kondaiah, Denduluru Post, West Godavari District, Andhra Pradesh, India. [A]
 Hale, John S., chief engineer, Litchfield, Whiting, Bowne and Associates, Viale Castro Pretorio 116, Rome, Italy.
 Indian Standards Institution, G. L. Gulati, 2-21, First Line Beach, Madras 1, India.

Indian Standards Institution, A. B. Rao, General Assurance Bldg., 232, Dr. Dadabhai Naoroji Rd., Bombay, India.
 Indian Standards Institution, P-11 Mission Row Ext., Calcutta 1, India.
 Kat, Dirk, managing director, Rontgen Technische Dienst n. v., Delftweg 144, Rotterdam 3, The Netherlands.
 Middletown, T. R., director of research, English Steel Corp., Ltd., River Don Works, Box 57, Sheffield 9, England.
 Moirard, Jean Claude, chief, Materials Dept., Esso Standard, S.A.F., 82 Avenue des Champs Elysees, Paris 8, France.
 Moncayo, Gustavo A., civil engineer, Ministerio de Obras Publicas, Chile 1267, Quito, Ecuador. For mail: Olmedo 1433, Quito, Ecuador.
 Nahringsbauer, Gunther, Lumalampan A. B., Stockholm 20, Sweden. [A]
 Palmgren, Hans, doctor of technology, Trelleborgs Gummifabriks AB, Trelleborg, Sweden.
 Plet-Beaupre, M., vice-president, Bureau de Normalisation du Petrole, 16, Avenue Kléber, Paris 16, France.
 Portnoi, M., Société Alstom, Belfort, France.
 Pringle, J. B., staff engineer, quality analysis, Bell Telephone Company of Canada, 1050 Beaver Hall Hill, Montreal, P. Q., Canada.
 Rhodesia, Division of Roads & Road Traffic, materials engineer, Box 8110, Causeway, Salisbury, Rhodesia and Nyasaland.
 Roiston, William H., consulting engineer, Associated Engineering Services, Ltd., 2256 W. Twelfth Ave., Vancouver 9, B. C., Canada.
 Saskatchewan Research Council, Library, A. E. Philp, librarian, University of Saskatchewan, Saskatoon, Sask., Canada.
 Schillknecht, E., Freilagerstr. 11, Zurich 9/47, Switzerland.
 Siribaed-Bisuddhi, Suthee, 2nd class laboratory officer, Appraisalment and Laboratory Div., Customs Dept., Klogtoey, Bangkok, Thailand. For mail: 41 Boonsiri Rd., Bangkok, Thailand.
 Stuart, T. C., director, Dominion Welding Engineering Co., Ltd., 6898 Norte Dame St., E., Montreal 5, P. Q., Canada.
 Stüssi, Fritz, professor, Ackermannstr. 17, Zurich 44, Switzerland.
 Swain, L. W., development engineer, Emco, Ltd., Dundas St., London, Ont., Canada.
 Villani, Vito A., structural engineer, soil testing laboratory, Sauti, Consulting Engineers, Box 10, Ahwaz, Iran.
 White, Arthur F., field engineer, Montreal Engineering Co., Ltd., 250 St. James St., W. Montreal 1, P. Q., Canada. For mail: 5465 Westminster Ave., N., Apt. 12, Cote Saint Luc, Montreal 29, P. Q., Canada. [A]
 Widmont, J. C., Jr., consultant, 4138 Mantova Dr., Los Angeles 8, Calif. For mail: Industrial Advisory Corp., 16 rue du Marche, Geneva, Switzerland.



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BOOKSHELF

(Continued from p. 90)

Fine Particle Measurement

Clyde Orr, Jr., and J. M. Dallavalle; The Macmillan Co. (1959); 353 pp.; \$10.50.

Reviewed by Robert A. Baker, Franklin Institute, Philadelphia, Pa.

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(Continued on page 112)



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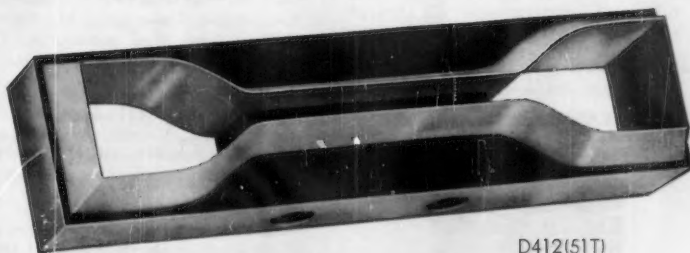
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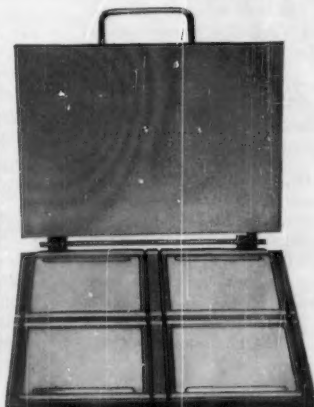
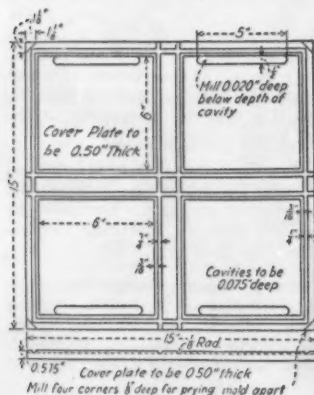
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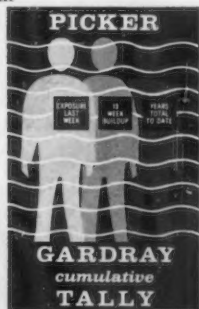
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104

NEWS OF MEMBERS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

The American Society for Metals, in ceremonies at the National Metals Exposition and Congress, presented **Edgar C. Bain**, retired assistant vice-president of operations, U S. Steel Corp., Pittsburgh, Pa., and **Earl C. Smith**, chief metallurgist and director of research, Republic Steel Corp., Cleveland, Ohio, with Honorary Memberships in the Society.

Jose Aleman, is now a chemist with the Monsanto Chemical Co., Plastics Div., Springfield, Mass. He was formerly with the Polymer Research Inst., Polytechnic Institute of Brooklyn.

Fred W. Argue has been appointed president, Stone & Webster Engineering Corp., Boston, Mass. He had been vice-president and engineering manager.

Robert D. Atkins, formerly consulting engineer, Dunphy Associates, Inc., St. Paul, Minn., is mechanical engineer, Minnesota Mining and Mfg. Co., St. Paul, Minn.

O. P. Beckwith, formerly in charge of quality control, The William Carter Co., Needham Heights, Mass., is now director of quality control, Ludlow Manufacturing and Sales Co., Needham Heights, Mass.

M. Berdick, prior to his election as vice-president, was director of research, Evans Research and Development Corp., New York, N. Y.

D. H. Blackmar was appointed chief metallurgist, Talon Inc., Meadville, Pa. He had been chief metallurgist, LeRoi Div., Westinghouse Air Brake Co., Milwaukee, Wis.

W. Boden, BTR Industries, Ltd., Herga House, Vincent Square, London, England, retired recently. Mr. Boden represented his company's membership in the Society.

Lawrence C. Brunstrum, section leader in lubricants research, Standard Oil Co., Whiting, Ind., has been selected chairman of the General Technical Committee of the National Lubricating Grease Inst.

Howard Cary, president of Applied Physics Corp., Monrovia, Calif., has been elected to the Board of Directors of Varian Associates.

Miles N. Clair, president, The Thompson and Lichtner Co., Brookline, Mass., and vice-president of ASTM, has been elected to membership on the ASA Board of Directors to fill out the unexpired term of C. W. Bryan, Jr., who had been serving on the Board on the nomination of ASCE. Mr. Clair is serving as the representative of the ASCE Standards Committee.

Gilbert L. Cox is affiliated with The International Nickel Co., Inc., Research

on Nickel Alloys, Bayonne, N. J. He had been technical manager, Whitehead Metals, Inc., Rochester, N. Y.

Lloyd A. Cummings retired Jan. 1, 1960, as vice-president of manufacturing, Marlin-Rockwell Corp., Jamestown, N. Y. Mr. Cummings will continue to hold his post as a member of the board of directors, and his services will be available to the company on a consulting basis.

George H. Daigle has joined the Norma Hoffmann Bearings Corp., Shelton, Conn., as engineer. Formerly he was an engineer with Rocket Valve Corp., Littleton, Colo.

K. E. DeRosay retired recently from the Sun Oil Co., Philadelphia, Pa. Mr. DeRosay had been a member of Committee D-2 on Petroleum Products and Lubricants for 22 years.

G. E. Detwiler is now mechanical engineer, Lawrence Radiation Laboratory, Livermore, Calif. He had been design engineer, North American Aviation, Inc., Los Angeles, Calif.

James G. Dick has been appointed manufacturing manager of all divisions of the Canadian Bronze Co. Ltd. Previously he had been in charge of research and development.

C. F. Doughman, chief engineer, Electrolux Corp., Old Greenwich, Conn., retired recently. Mr. Doughman represented his company in Society membership.

Joseph V. Emmons, following his recent retirement as metallurgical and research consultant, The Cleveland Twist Drill Co., Cleveland, Ohio, will do consulting work in the fields of physical metallurgy and metallurgical research at 3284 Chadbourne Road, Cleveland 20, Ohio.

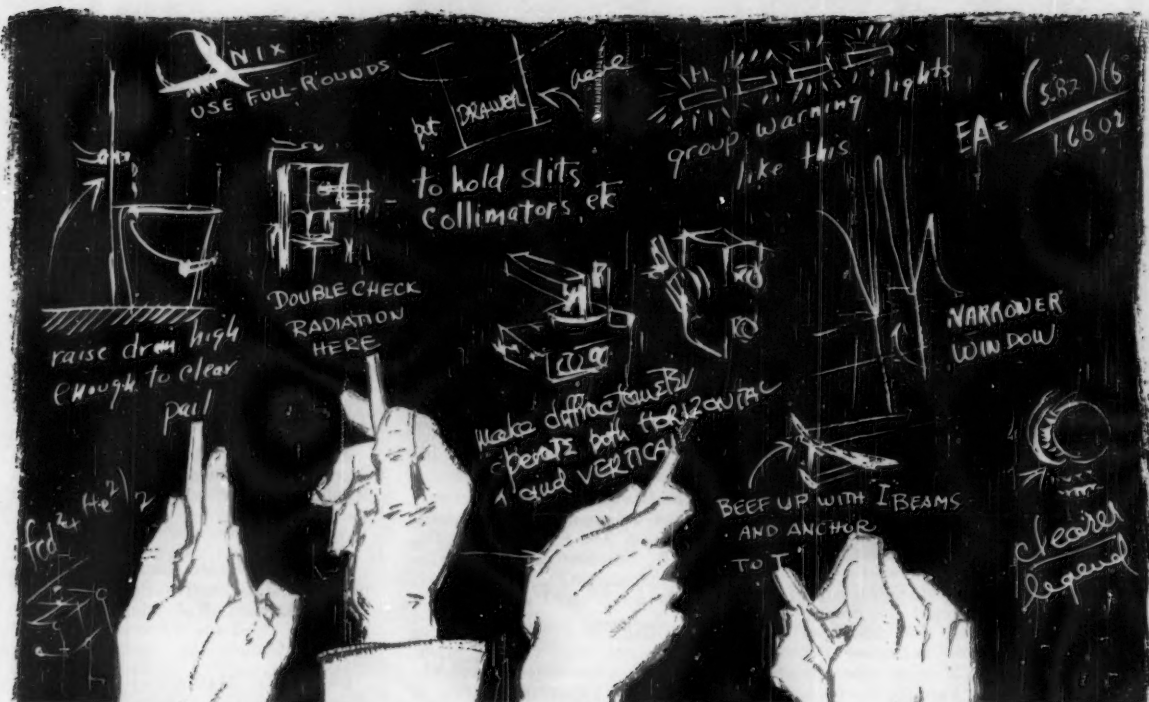
Joseph M. Fink, senior associate structural engineer, City of Detroit, Mich., retired Dec. 1, 1959. For many years, Mr. Fink represented the City of Detroit on Committees C-15 on Manufactured Masonry Units, C-17 on Asbestos-Cement Products, and C-18 on Natural Building Stones. He was also a member of the Detroit District Council.

Sheldon E. Fitterer is now affiliated with Stanley Publishing Co., Philadelphia, Pa., as district manager. Formerly, he was regional manager, Electronic Periodicals, Inc., Los Angeles, Calif.

Richard J. Frazier, former vice-president and director of production, Anchor Concrete Products, Inc., Buffalo, N. Y., is now director of research, Harry T. Campbell Sons' Corp., Towson, Md.

(Continued on p. 106)

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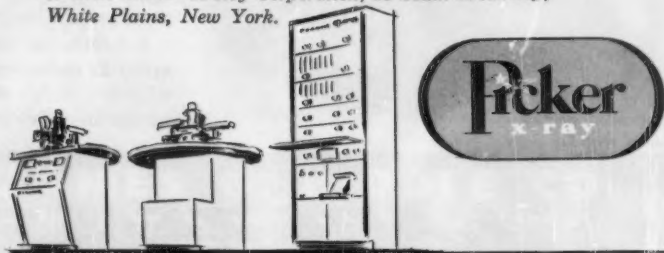
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NEWS OF MEMBERS

(Continued from p. 104)

John H. Gibbud, former physicist and professional engineer, N. Providence, R. I., is manager, The Howe Scale Co., Rutland, Vt.

Gorden B. Guenther is now director of engineering, Industrial Electronic Rubber Co., Solon, Ohio. Previously he was product engineer, Thompson Ramo Woolridge, Inc., Cleveland, Ohio.

Norman G. Hallin is affiliated with Buena Engineering Services, Inc., Ventura, Calif., as president. Previously he was general manager for Saticoy Rock Co., Ventura, Calif.

Frank E. Harness is now chief metallurgist, Ductile Iron Foundry, Inc., Stratford, Conn. He had been metallurgist, Gardner-Denver Co., Quincy, Ill.

E. M. Hayden retired Dec. 31, 1959, as vice-president and technical director, The Stanley Chemical Co., East Berlin, Conn. Mr. Hayden joined the Society in 1941 and since that time had been active in the work of Committees B-8 on Electrodeposited Metallic Coatings and D-1 on Paint, Varnish, Lacquer, and Related Products.

Francis M. Howell, chief, Mechanical Testing Div., Alcoa Research Laboratories, New Kensington, Pa., retired recently. Mr. Howell is a 40-year mem-

ber of the Society and will continue his interest in ASTM activities. He is a member of the Administrative Committee on Papers and Publications.

Thomas A. Hunter, prior to becoming affiliated with The Cleveland Pneumatic Tool Co., Cleveland, Ohio, as manager, analytical sciences, was manager, Ampatco Laboratories, Cleveland, Ohio.

A. F. Ilacqua retired recently from American Steel and Wire Div., U. S. Steel Corp., Cleveland, Ohio, as divisional metallurgist. He joined the Society in 1947 and has represented his company on Committee A-1 on Steel since 1943.

N. Isenberg, following his retirement on Feb. 1, 1960, as chief chemist, Inland Steel Co., East Chicago, Ill., is associated with Freeman Coal Mining Corp., Chicago, Ill., as a consultant.

Louis J. Jacobs, formerly director of research and development, The Ramtite Co., Division of The S. Obermayer Co., Chicago, Ill., has been appointed vice-president, manufacturing and research, for both Obermayer and Ramtite.

Clyde W. Kelly, director of engineering research, Fenestra, Inc., Detroit, Mich., retired recently after 40 years with the firm. Mr. Kelly joined the Society in 1937 and since 1953 participated in the work of Committee E-5 on Fire Tests of Materials and Construction.

Richard G. Kimbell, director, Technical and Lumber Standards Div., National

Lumber Manufacturers Assn., Washington, D. C., retired recently. For many years Mr. Kimbell represented the Association in ASTM membership.

Jerome J. Kipnees is now associated with the Atlantic Gunned Paper Corp., Brooklyn, N. Y., as vice-president. He had been vice-president, Container Laboratories, Inc., New York, N. Y.

A. T. Larned retired recently from Ebasco Services, Inc., New York, N. Y. Mr. Larned represented his company's sustaining membership in the Society.

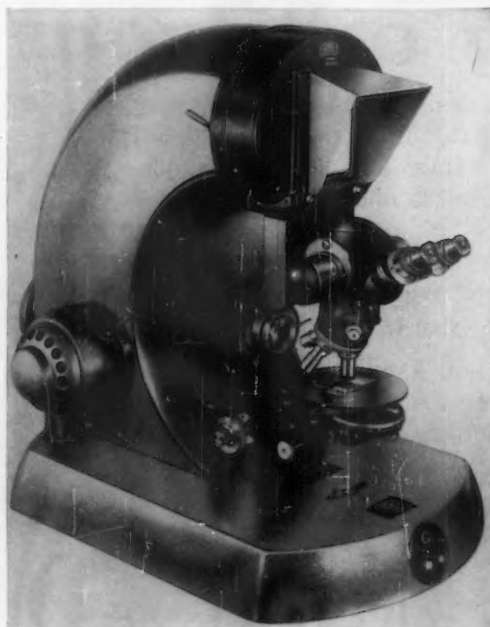
Cord Lipe has been appointed chief engineer, adhesives, The Permafuse Corp., Westbury, N. Y. Formerly he was manager of the Adhesives Div., Cycleweld Cement Products Div., Chrysler Corp., Trenton, Mich.

H. M. Lyster, after having served for 29 years as general manager of Dominion Welding Engineering Co., Ltd., Montreal, Canada, was elected president Jan. 1, 1960.

D. H. MacDonald, former director of research and engineering, Revere Corporation of America, Wallingford, Conn., is president, Madison Laboratories, Inc., Madison, Conn.

George G. Manov has accepted a position with the National Aeronautics and Space Administration, Washington, D. C. He was formerly technical director, Tracerlab, Richmond, Calif.

(Continued on p. 107)



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NEWS OF MEMBERS

(Continued from p. 106)

Herman F. Mark of Brooklyn Polytechnic Institute received the 1960 Nichols Medal of the New York Section of the American Chemical Society. He was cited for his "brilliant advancement of polymer science towards useful ends through pioneering theoretical and experimental development of new concepts of molecule architecture and macromolecule chemistry," and for his "inspired communication of polymer developments through teaching, writing, editorship, and personal contact affecting a continued widespread growth of mature understanding of large molecules." Prof. Mark delivered the 1959 ASTM Marburg Lecture.

Hugh R. McKee is now instructor of chemical engineering, Tulsa University, Tulsa, Okla. He was with Bareco Wax Co., Division of Petrolite Corp., Kilgore, Tex., as chemical engineer.

J. L. Menson has been elected vice-president, engineering, Combustion Engineering, Inc., New York, N. Y. Mr. Menson represents his company's sustaining membership in the Society.

Carl A. Menzel, consultant on concrete technical problems, Portland Cement Assn., Chicago, Ill., retired Sept. 30, 1959. Mr. Menzel is a 25-year member of ASTM, and represented PCA on Committee E-5 on Fire Tests of Materials and Construction for an equal number of years. Other Society activities included Committees C-15 on Manufactured Masonry Units, C-12 on Mortars for Unit Masonry, E-6 on Methods of Testing Building Constructions, and the Chicago District Council. Mr. Menzel will continue his interest in ASTM by retaining his individual membership.

Howard C. Meyers, Jr., former engineer of tests, Midvale-Heppenstall Co., Philadelphia, Pa., has been made director of metallurgy.

G. S. Mikhlapov has been elected president, Brush Beryllium Co., Cleveland, Ohio. He had been executive vice-president.

Bertram J. Milleville, former director, engineering and research, was elected vice-president of engineering and research, Ohio Injector Co., Wadsworth, Ohio.

Austin H. Morgan, Jr., has joined the Standard Lime & Cement Co., Baltimore, Md., as technical service engineer. Previously he was a trainee with the Highway Research Council, Charlottesville, Va.

William S. Morrison, Jr., is affiliated with E. I. du Pont de Nemours & Co., Wilmington, Del., in the capacity of special service engineer. Formerly, he was assistant to technical secretary, American Welding Society, New York, N. Y.

J. C. Mosteller, vice-president and technical director, Royal Lubricants Co., Hanover, N. J., has been promoted to executive vice-president.

(Continued on p. 108)



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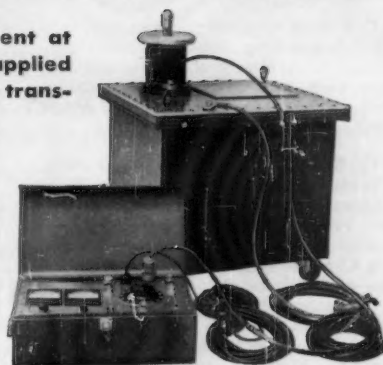
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NEWS OF MEMBERS

(Continued from p. 107)

Herman L. Paul, Jr., prior to becoming director of research and development, General Kinetics Corp., Englewood, N. J., was chief engineer, P-K Industries, Inc., Arlington, N. J.

C. F. Peck, formerly professor and head, Civil Engineering Dept., Cooper Union for the Advancement of Science and Art, New York, N. Y., is now chief engineer, Structural Products Div., Ceco Steel Products Corp., Chicago, Ill.

C. E. Proudley has retired as state materials engineer, North Carolina State Highway Commission, Raleigh, N. C. Mr. Proudley represented the Commission on ASTM Committee C-9 on Concrete and Concrete Aggregates and Committee D-4 on Road and Paving Materials, and is a member of the Washington, D. C., District Council. He will continue his Society activities through personal membership. After an extended vacation, Mr. Proudley will assume duties as director of engineering and executive secretary of the Carolinas Ready-Mix Concrete Assn.

E. N. Rockwell, Jr., is now associated with Scientific Testing Service, Los Angeles, Calif., as general manager. Previously he was affiliated with Smith-Emery Co., Los Angeles, Calif., as assistant chief chemist.

Frederick C. Sanderson is now engineer, Moran, Proctor, Mueser & Rutledge, New York, N. Y. He had been supervising engineer, Seelye, Stevenson, Value & Knecht, New York, N. Y.

Ralph A. Schaefer, director of research and development, The Bunting Brass and Bronze Co., Toledo, Ohio, has been named director of an enlarged department of engineering and research. Dr. Schaefer will be in charge of research, development, processing engineering, and inspection.

A. E. Schoenfeldt, assistant general superintendent, Buffalo Bolt Co., North Tonawanda, N. Y., retired recently. Mr. Schoenfeldt joined the Society in 1947.

Raymond J. Schutz has been appointed vice-president, research and development, Sika Chemical Corp., Passaic, N. J.

R. C. Slocumb has retired from The Baltimore & Ohio Railroad Co., Baltimore, Md. Mr. Slocumb represented his company on Committee A-1 on Steel.

R. L. Smith is now head, Dept. of Metallurgical Engineering, The Michigan College of Mining and Technology, Houghton, Mich. He had been in the metallurgy section of The Franklin Institute, Philadelphia, Pa.

A. B. Stone, chief engineer, Norfolk & Western Railway Co., Roanoke, Va., retired in June 1959. Mr. Stone had been a member of the Society since 1949.

John D. Sullivan, technical director, Battelle Memorial Institute, Columbus, Ohio, was honored for distinguished achievement in the field of ceramics by receiving the medal and scroll symbolizing the Albert Victor Bleining Memorial Award. The award is presented by the Pittsburgh Section of the American Ceramic Society.

C. C. Sutton, formerly laboratory director, packaging, laboratory, General Foods Corp., Research Center, Tarrytown, N. Y., is now associated with The Quaker Oats Co., Barrington, Ill.

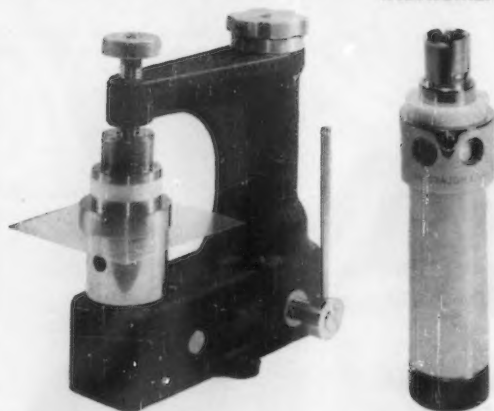
I. L. Tyler, manager, Field Research Section, Portland Cement Assn., Skokie, Ill., has been appointed research counselor in the Research and Development Div.

Stanton Umbreit, metallurgist, Tube Div., Radio Corporation of America, Harrison, N.J., retired recently. Mr. Umbreit joined the Society in 1937 and since that time has been very active in Committees B-4 on Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts, and F-1 on Materials for Electron Tubes and Semiconductor Devices. He also represented Committee B-4 on Committee E-1 on Methods of Testing, and Committees B-4 and F-1 on the joint Coordinating Committee. In recognition of his work, Committee F-1 elected him to Honorary Membership.

Emerson Venable has been elected secretary and membership chairman of the Association of Consulting Chemists (Continued on p. 110)

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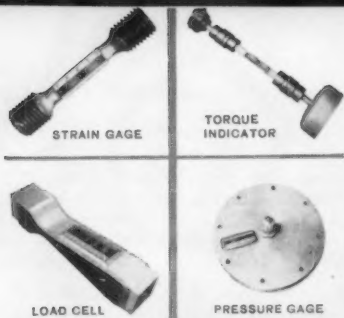
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NEWS OF MEMBERS

(Continued from p. 108)

and Chemical Engineers. Mr. Venable is a consulting chemist and engineer in Pittsburgh, Pa. The January ASTM BULLETIN erroneously reported him as having been elected treasurer.

Louis J. Venuto, associate director of technical service, Columbian Carbon Co., Pigment Div., New York, N. Y., delivered the first PaVaC Lecture at the New York Society of Paint Technology. His topic was "Carbon Black—the Tiny but Mighty Particle."

John E. Viscardi is a staff engineer with Burns & Roe, Inc., Hempstead, N. Y. He was senior engineer, Nuclear Development Associates, Inc., White Plains, N. Y.

William B. Wallis has been named consulting engineer, Strategic Materials Corp., New York, N. Y., where he will assist in the promotion of the Strategic Udy process. He recently resigned after 21 years as president of Lectromelt Furnace Div., McGraw-Edison Co., Pittsburgh, Pa.

Henry H. Waples, architectural engineer, Office of the Supervising Architect, Public Buildings Administration, Washington, D. C., retired Dec. 31, 1959. Mr. Waples was a long-time mem-

ber of the Society, and had been active in Committees C-2 on Magnesium Oxide and Magnesium Oxysulfate Cements, C-7 on Lime, and C-9 on Concrete and Concrete Aggregates.

Mary Wurga, professor of physics and director of spectroscopy laboratory, University of Pittsburgh, Pittsburgh, Pa., is on leave of absence to be executive secretary of the Optical Society of America, setting up its new executive office in Washington, D. C.

O. G. Wilbur retired recently from The Baltimore & Ohio Railroad, Baltimore, Md. For 10 years, he represented the Committee on Masonry of the American Railway Engineering Assn. on ASTM Committee C-12 on Mortars for Unit Masonry.

W. R. Willets, Titanium Pigment Corp., Service Laboratories, New York, N. Y., has been elected to the Governing Board of the American Institute of Physics.

John W. Winkworth, before joining technical sales, J-W Materials Inc., Napoleon, Ohio, was with Winkworth Fuel and Supply Co., Detroit, Mich.

E. J. Woodward, Jr., until recently construction manager, Kenneth H. Golden Co., Inc., San Diego, Calif., is now vice-president, Industrial Asphalt of California, Los Angeles, Calif.

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DEATHS

R. C. Angell, director of development, The S. S. White Dental Manufacturing Co., Staten Island, N. Y. (recently). Mr. Angell represented his company's membership in ASTM.

Myrl N. Davis, senior scientific consultant, Kimberly-Clark Corp., Neenah, Wis. (Dec. 22, 1959). Mr. Davis represented his company's sustaining membership in the Society.

Fred P. Diener, director, tests and research, Universal Atlas Cement Div., United States Steel Corp., New York, N. Y. (Jan. 12, 1960). Mr. Diener's Society membership dated back to 1945 as did his membership on Committee C-1 on Cement.

Carl R. Fellers, University of Massachusetts, Institute of Food Technology, Amherst, Mass. (Feb. 22, 1960). Dr. Fellers was a consulting member of Committee F-2 on Flexible Barrier Materials.

Dan Fretwell, owner, Aetna Engineering Co., Van Nuys, Calif. (recently).

Glen F. Jenks, retired, U. S. Army, La Jolla, Calif., (Jan. 1, 1960). Col. Jenks joined ASTM in 1916 and resigned his membership in 1945. During that time he represented the U. S. Army on many technical committees.

A. E. Martin, director of chemistry and metallurgy, Ainsworth-Precision Castings Co., Division of Marsco Corp., Fayetteville, N. Y. (recently). Mr. Martin represented his company in Society membership and also on ASTM Committees B-6 on Die-Cast Metals and Alloys, B-3 on Corrosion of Non-Ferrous Metals and Alloys, B-7 on Light Metals and Alloys, Cast and Wrought, and E-2 on Emission Spectroscopy.

C. A. Maynard, vice-president, The Indiana Steel Products Co., Valparaiso, Ind. (Jan. 1, 1960). Mr. Maynard represented his company in Society membership and on Committee A-6 on Magnetic Properties.

T. Curtis McKenzie, owner, Solar Testing Service, Broward County International Airport, Fort Lauderdale, Fla. (July 4, 1959).

W. H. Millsbaugh, president, Centrifugal Steel, Inc., Sandusky, Ohio (April 21, 1959). Mr. Millsbaugh had been a member of the Society since 1945.

James A. Murray, associate professor, Dept. of Building Engineering and Construction, Massachusetts Institute of Technology, Cambridge, Mass. (March 4, 1960). Prof. Murray was a 30-year member of the Society and through the years was very active in committee work. His main interest was in Committee C-7 on Lime; he was a member of the committee since 1930, and from 1953 to the time of his death served as its chairman. He had been recently re-elected to this office for the coming two-year term. Prof. Murray also participated in the activities of Committees C-12 on Mortars for Unit Masonry, E-1 on Methods of Testing,

C-2 on Magnesium Oxide Chloride and Magnesium Oxysulfate Cements, and C-9 on Concrete and Concrete Aggregates.

John E. Orrell, chief engineer, Shell Oil Co., Inc., Los Angeles, Calif. (Jan. 3, 1960). Mr. Orrell represented his company's membership in ASTM.

K. T. Potthoff, treasurer, U. S. Galvanizing and Plating Equipment Corp., Brooklyn, N. Y. (Nov. 6, 1959). Mr. Potthoff joined the Society and became a member of Committee A-5 on Corrosion of Iron and Steel in 1917.

J. H. Schneider, Elliot Co., Ridgway, Pa. (Oct. 2, 1959). Mr. Schneider represented his company on Committee A-6 on Magnetic Properties for five years.

Bradley Stoughton, Lehigh University, Bethlehem, Pa. (Dec. 30, 1959). Prof. Stoughton was a 50-year member of the Society, having joined in 1902. From 1935 to 1940 he represented the American Society of Metals on the Joint Committee on Definitions of Terms Relating to Heat Treatment of Metals.

Harry F. Thomson, American Concrete Inst., St. Louis, Mo. (Nov. 7, 1959). Mr. Thomson represented ACI on Committee C-9 on Concrete and Concrete Aggregates, and also served on the St. Louis District Council.

V. W. Whitmer, assistant chief metallurgist, Republic Steel Corp., Massillon, Ohio (Nov. 22, 1959). Mr. Whitmer was a member of ASTM Committees A-1 on Steel, A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, and B-2 on Non-Ferrous Metals and Alloys.

Charles S. Whitney, consulting engineer, Milwaukee, Wis. (Oct. 26, 1959). Mr. Whitney was a 30-year member of the Society.

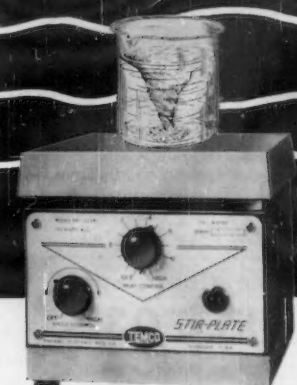
W. F. Zerbe, vice-president in charge of operations, Phoenix Steel Corp., Plate Div., Harrisburg, Pa. (Aug. 1959). For many years, Mr. Zerbe represented his company in Society membership and on Committee A-1 on Steel.

F. P. Zimmerli, consultant, Lyons, N. Y. (Dec. 12, 1959). Prior to his retirement, he was chief engineer, Barnes-Gibson-Raymond Div., Associated Spring Corp., Detroit, Mich. Mr. Zimmerli, a 30-year member of the Society, represented his company on Committees A-1 on Steel, B-4 on Metallic Materials for Electrical Heating, Electrical Resistance, and Electrical Contacts, and E-9 on Fatigue. He was a member of the Detroit District Council for many years, having served as vice-chairman from 1946 to 1948 and chairman from 1948 to 1950. In 1953 he was elected an Honorary Member of the District.

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BOOKSHELF

(Continued from p. 102)

terpretation of results, and limitations are considered for the various techniques described. Particle size measurement by microscopic and sieving methods, sedimentation, inertial and radiation scattering, and transmission methods are described in four separate chapters. Surface-area determination through permeability, gas absorption, liquid-phase sorption, and other methods compose the next four chapters. A final chapter treats pore size and pore-size distribution.

As an example of the method of presentation, the Harkins-Jura (HJa) method for surface area will be considered. This method is considered to be absolute and is based on the thermodynamic principle that adsorbed films on solids are similar to liquid-vapor films described by the Gibbs equation. The theoretical discussion includes a brief mathematical development of the relationship of the parameters involved. The calorimeter used in the HJa method is described and depicted in a cutaway view and the procedure described.

A liberal bibliography (over 600 references) is provided. An appendix of tabular data permits comparison of the results obtained by methods applied to various materials.

Without any doubt this is the most authoritative and complete treatment of the field. It would be markedly improved by enlargement of the subject index. The index is far too brief for a

book such as this. This makes it difficult to locate specific subjects quickly. It would also preclude the use of the book by the casual user unacquainted with the content.

The book is recommended for engineers, chemists, and physicists in any field in which fine particles are involved.

How to Design and Buy Investment Castings

R. H. Herrmann; Investment Casting Inst., Chicago, Ill., 1959; 176 pp.; 6 by 9 in.; illus.; \$3.95.

Reviewed by L. L. Wyman, National Bureau of Standards, Washington, D. C.

THIS MANUAL has been prepared by contributors from the member companies of the ICI, and is intended to better acquaint the potential user of investment castings with the process, as well as to serve as a reference for designers and buyers. The opening paragraphs are remiss in not emphasizing to the novice that this is an expensive (as investment castings go) specialty process that justifies its existence and rapid growth by being capable of producing nearly completed items in materials that cannot be fabricated by normal means, and in accomplishing complexities of shape, dimensional accuracy, and quality of finish that permit the production of parts quite unobtainable by conventional methods and at costs far below

those accumulated by fabricated assemblies.

Following several pages devoted to describing the process in quite general terms, about a quarter of the manual is devoted to materials under the title "What Metal to Use?" Unfortunately, the question is never answered. The reader is first presented with a description of some of the mechanical properties and tests of materials, not too accurately interpreted; this is followed by an excellent compilation of all the general casting and materials specifications, including complete specification cross-referencing. These provide a very good set of references for materials currently in use, but imply that the selection thereof be on the recommendation of the producer.

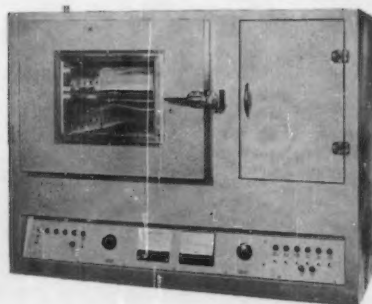
While the comprehensive discussion of vacuum processes is quite informative, the stated purposes are weakly presented. Similarly, the section on casting design seems to be directed more toward the prospective buyer than toward the casting designer. On the other hand, the subjects of casting inspection and quality control seem quite adequately discussed. The concluding glossary terms, in which one can recognize a number of old reliables, does include some dubious statements.

For the prospective users of investment castings, the manual should be quite instructive, and it also provides an excellent reference for current materials, tests, and quality control.

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Chart Drive: synchronous, 1 inch per minute standard; other speeds of 1/10, 3/10, 3 or 12 inches per minute available by purchase of interchangeable motors.

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NEWS NOTES ON

Laboratory Supplies and Testing Equipment

Note. This information is based on literature and statements from apparatus manufacturers and laboratory supply houses. The Society is not responsible for statements advanced in this publication.

CATALOGS & LITERATURE

Hi-Pot Testing—A 12-page application bulletin, *Practical Hi-Pot Testing*, is offered. Separate sections cover a-c and d-c breakdown testing, with discussion on nondestructive tests of dielectric strength on wiring harnesses, motors, cables, solenoids, thermostats, and similar equipment.

Associated Research, Inc. 6202

Ultrasonic Thickness Testers—two portable thickness testers, Audigage Models 5 and 6 are detailed in an 8-page *Bulletin No. A-200*, now available. These ultrasonic gages permit measurement of thickness from only one side of a wide variety of materials—metal, glass, plastic—by relating a variation in thickness to the change in resonant frequency.

Branson Instruments, Inc. 6203

House Organ—Now available is the fourth issue, Volume V, of the Buehler, Ltd. bimonthly external house organ, *Metal Digest*. This particular issue places emphasis on the importance of proper coarse grinding in achieving better final polishing.

Buehler, Ltd. 6204

Accelerometers—A new line of true compression accelerometers, Series 200, for use in applications where size and weight are critical factors, is described in a new bulletin.

Columbia Research Laboratories 6205

Laboratory Glassware—Some 78 new items are listed in a supplement to the Pyrex Brand laboratory glassware catalog issued recently.

Corning Glass Works 6206

Laboratory Catalog—Packed with hundreds of items of laboratory and quality-control equipment, engineering and technical instruments; optical apparatus and parts; mathematical and scientific books and training aids; a new 128-page catalog has been issued. Included are measuring magnifiers, pocket comparators, illuminators, projection sets, and many other instruments.

Edmund Scientific Co. 6207

Resistance Bulb—A new data file, *Englehard Platinum Resistance Bulb*, has been published. This file reveals the availability of two types of precision resistance spirals and provides data on these resistance elements.

Englehard Industries, Inc. 6208

Spectrograph—*Bulletin FS-214* describes Duo-Spectral for semiquantitative and qualitative analysis.

Fisher Scientific Co. 6209

Infrared Heating—A comprehensive 20-page infrared bulletin, 2 colors, gives complete information on infrared heating: its principles, advantages, applications (illustrated), and typical standard systems.

Postoria Corp. 6210

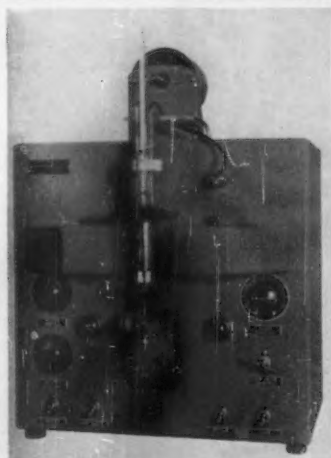
Optical Benches—Now available is a 28-page *Bulletin No. 156-59* describing the complete line of Gaertner optical and instrument benches. The new bulletin gives general features, descriptions, and specifications for lathe-bed-type benches, double-rod benches, single-rod benches, and accessories.

The Gaertner Scientific Corp. 6211

Precision Meters—An all-inclusive Meter Master Chart, for quickly determining the one meter that combines up to 23 ranges to meet individual measuring needs, is among the many highlights of the 20-page catalog recently released.

Greibach Instruments Corp. 6212

(Continued on p. 116)



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CATALOGS LITERATURE

(Continued from p. 114)

Potentiometer Wire—An 8-page Bulletin No. 111 containing detailed technical data on Chromel-R, a new modified 80-20 type nickel-chromium 800-ohm alloy for precision wire-wound resistors and potentiometers, has been published.

Hoskins Mfg. Co.

6213

Peak Pressure Gage—A 4-page folder describing and illustrating a new hydraulic peak-pressure gage that indicates peaks using full-scale ranges of 0 to 4000 and 0 to 10,000 psi, can also be used for permanent recording. It gives complete specifications, method of operation, and typical wave forms encountered.

Hydel, Inc.

6214

Glassware—Release of a new Catalog Supplement SP-63 has been announced. Entitled "More Kimble Laboratory Ware with Teflon Stopcock Plugs," the 12-page supplement will cover 38 listings, all in a variety of sizes.

Kimble Glass Co.

6215

Data Logging System—A new two-page Application Data Sheet N-07(1) describing a 100-channel sequential data logging system is now available. The data sheet describes the use of this data system to record the test results of components being exposed to nuclear radiation. The operation of this equipment is explained with the aid of a schematic diagram and a description of the system. Complete specifications are listed, including modes of operation, time per channel, visual displays, and channel switching.

Leeds & Northrup Co.

6216

Hot Plate—A new pamphlet illustrating and describing the 1960 Model Pyrodisc portable electric hot plate is available.

Lindberg Engineering Co.

6217

Centrifuges—New 2-color, 16-page illustrated catalog announces 13 improved models of the super-speed centrifuges. Complete with specifications and other information, the catalog is attractively printed with photographs, and diagrams, showing full details.

Loures Instrument Corp.

6218

Solid-State Sequencer—New 8-page color brochure on a static time sequencer represents the newest development in solid-state magnetic switching. The time sequencer is a self-contained programmer which provides control power signals for automatically performing test operations such as missile count down in sequence. The equipment is also applicable to automated industrial process control.

Magnetic Amplifiers, Inc.

6219

Glassware—New 32-page catalog describes glass apparatus, electronic equipment, heating mantles, clamps, and burets.

Micro-Ware, Inc.

6220

Force Rings—A 4-page, 2-color brochure, Bulletin No. 173, describing the new force ring transducer, is now available. The new bulletin describes in detail the proving ring and differential transformer—components which make up the new force ring transducer. Specifications covering both components are included and performance curves point up the accuracy of the proving ring.

Morehouse Machine Co.

6221

Etcher—A cathodic vacuum etcher,

Model 4 CVE, is described in a 6-page folder. Suitable for preparing metals, ceramics, and cermets for examination of grain size, structure, inclusions, etc.

Nuclear Materials & Equipment Corp.

6222

Gamma Spectrometer—A data folder gives the details on a new gamma spectrometer system designed to eliminate the "dark current" defect common to conventional systems. Known as Model GSS-1, the system is said to offer better resolution over a wider range, and to provide greater precision in gamma spectroscopy than possible with any other equipment now available.

Nuclear Measurements Corp.

6223

Laboratory Catalog—A 16-page catalog describing the line of scientific equipment has been announced.

Phipps & Bird, Inc.

6224

Conversion Factors—A reference table for engineers and other executives in wall-chart form has been published. This conversion chart includes common conversions such as inches to centimeters or watts to horsepower, as well as many conversions that are difficult to locate in reference manuals.

Precision Equipment Co.

6225

Portable Vacuum Oven—A unit combining the features of a vacuum oven, drying oven, and desiccator is now offered. Known as the heated vacuum desiccator, the 8½-lb. easily moved unit can be used for rapid evaporation of solvent traces, moisture testing, or glassware drying.

Precision Scientific Co.

6226

(Continued on p. 117)

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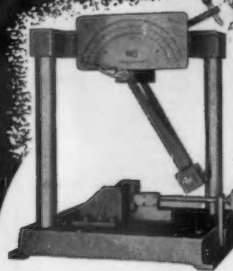
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CATALOGS & LITERATURE

(Continued from p. 116)

Microwave Applications—A full-color, single-sheet data page, discussing electrical, chemical, and physical properties of Rexolite 2200, is now available.

Rez Corp.

6227

Testing Machines—A new comprehensive 40-page catalog on Reihle universal testing machines is now available. The catalog is fully illustrated with photographs, diagrams, scale ranges, and specification tables. It is standard file size and punched for 3-ring folders.

Reihle Testing Machines Co.

6228

Chemical Catalog—A 12-page brochure describes spectrochemical and analytical services.

Spectrochemical Laboratories, Inc.

6229

Proving Rings—A 4-page illustrated booklet, *Bulletin No. P-260*, describes complete lines of dial-indicator and optical proving rings—instruments of force measurement used to calibrate other devices and to measure applied loads accurately. This booklet describes what they are, why they work, how they are made, and their general characteristics. Also described is a lightweight 150,000-lb capacity calibration press in which small devices can be calibrated with a proving ring.

Steel City Testing Machines, Inc.

6230

Memory Unit—A new 4-page bulletin describing a series of general-purpose high-speed memory units is available. The new memory units, designated Type RB, are made in a wide range of sizes from 128 to 1024 words and from 4 to 24 bits per word.

Telemeter Magnetics, Inc.

6231

Balances—The first complete catalog of American Mettler balances has been issued. The new brochure lists 39 different balances, complete with tabulated performance data, applications, and prices. Featured is a wide range of analytical, general-purpose, and precision balances, as well as Mettler's unique check weighing and sorting balances, automatic filling balance, recording, and remote-control systems.

Will Corp.

6232

LABORATORY ITEMS

Vibration Fatigue Testers—Two versions of an improved vibration fatigue testing machine in which a vertical table movement is controlled entirely by a piston-operated mechanism have been announced. They are Models 150 VP-D and 150 VP-T. Table load capacity is 150 lb at 10-g acceleration. For g values higher than 10 the load must be reduced. Maximum capacity is approximately 23 g. Vibration is produced in simple harmonic motion.

All American Tool & Mfg. Co.

3323

Oscillator—Pulses of $\frac{1}{2}$ microsec at any frequency between 0.5 and 150 Mc are now available on the high-powered pulsed oscillator, PG-650-C. The pulses may be continuously varied over a 10 to 1 range in steps up to 50 microsec. The peak amplitude is 300 v peak-to-peak into a 93-ohm load. The unit can be self-triggered or synchronized externally up to 3 kc P.R.F. Calibrated delay

(Continued on p. 118)

Multi-Purpose SCHENCK Fatigue Testing Machines

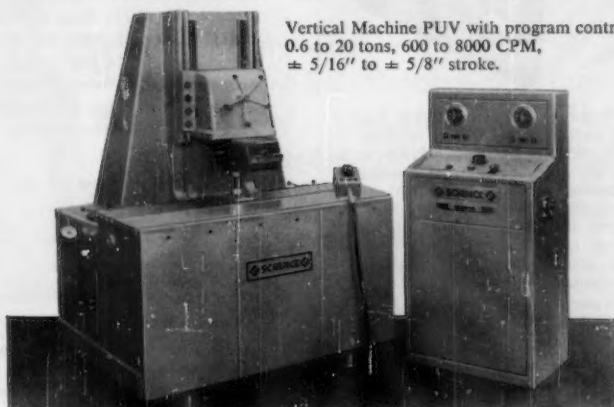
HIGH SPEED—COMPLETELY ADJUSTABLE FOR RESEARCH AND PRODUCTION TESTING

Exclusive Schenck fatigue testers offer more outstanding features. Test tensile strength, torsion, bending fatigue of any material, soft (rubber-plastics) or hard (steels). Basic push-pull action. High speed cycling permits rapid plotting of S-N curves. Built-in controls provide infinitely variable adjustment for frequency range, static and dynamic loads. Patented optical system measures loads, provides continuous visual inspection. Rubber mounts eliminate special foundations.



Horizontal Machine PB with program control.
3 to 100 tons, 280 to 4500 CPM, $\pm 1''$ to $\pm 2''$ stroke.

The Schenck PB horizontal (above) with long stroke and additional low speed drive applies rapid stress reversals with high loads—provides closest possible simulation of operating conditions. The Schenck PUV vertical (below) features many exclusives capacities of PB, but saves space through vertical design which makes it the ideal laboratory testing machine.



Vertical Machine PUV with program control.
0.6 to 20 tons, 600 to 8000 CPM,
 $\pm 5/16''$ to $\pm 5/8''$ stroke.

Schenck horizontal type PP (not illustrated).
2 to 60 tons, 2000 to 2600 CPM, $\pm 3/16''$ to $\pm 9/32''$ stroke.

Various gripping devices, load multipliers, heating-freezing chambers and program controls available for most, if not all, models.

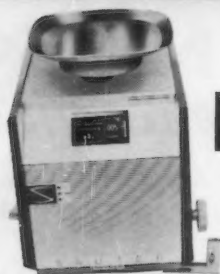
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- Pilot light indicates taring device is in use.
- Magnetic damping for quick oscillation and stability of projection scale.
- Lever locks mechanism for relocating balance.
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S 2000 — 2000g
S 4000 — 4000g

Measurements 9 7/8" W x 14 1/4" H x 12 1/4" D

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LABORATORY ITEMS

(Continued from p. 117)

ranges to 11,000 microsec are provided as well as external modulation of the pulse or radio frequency.

Arenberg Ultrasonic Laboratory, Inc. 3324

Potential Test—A new series of bench-type, semiportable, high-potential test sets with outputs to 30 kv, for determining dielectric strength in electrical power, electronic, and communication circuits, components, etc., has been announced.

Associated Research, Inc. 3325

Strain Gage—A unique photoelastic strain gage, designed with virtually zero lateral sensitivity, has been announced. Known as the B-L-H Strainline photoelastic strain gage, this device is a direct-reading, uniaxial strain indicator. Unlike other photoelastic strain devices, the Strainline gage indicates axial strain in the direction of gage application only. In addition to axial static and dynamic strains, lateral bending and torque are also indicated.

Baldwin-Lima-Hamilton Corp. 3326

Polarizing Microscope—A new research polarizing microscope has been announced. The newly designed LR Model, which replaces the LC Petrographic scope, will have research application in such fields as geology, mineralogy, crystallography, and physical chemistry.

Bausch & Lomb Optical Co. 3327

Recording Spectrophotometer—A new Spectronic 505 recording spectropho-

tometer at a cost up to 50 per cent lower than other recording instruments is announced. Outstanding features include automatic wavelength speed control, external dual lamphouse, air-cooled hydrogen lamp, built-in wavelength calibration, large samples compartment, and uniquely designed monochromator. The compact instrument has been constructed on a "building block" design which simplifies the removal and replacement of major components and accessories.

Bausch & Lomb Optical Co. 3328

Air Sampling Unit—This mobile field laboratory is equipped to make continuous quantitative analyses of contaminants in air samples drawn from the atmosphere and to chart a permanent record of the results. Housed in a paneled, 1959 Chevrolet step-van truck, the monitoring instrumentation includes four Beckman Series 70 air pollution analyzers and two Model 21 infrared analyzers.

Beckman Scientific and Process Instruments Div. 3329

Mechanical Convection Ovens—A recent invention improves temperature controls for ovens and equipment of similar nature. Replacing conventional on-off type resistance thermometers and multiple switch-type controls is a new Power-O-Matic 60 saturable power reactor control with a fail-safe device called Range-Lock.

Blue M Electric Co. 3330

Foam Tester—The Wohler foam tester is a portable instrument for determining the compression modulus or firmness of all types of flexible foams. It is suitable

(Continued on p. 120)

Atlas-Ometers

...Used all over the world

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| Dyestuffs and chemicals | Soaps and detergents |
| U.S. Government | Paint, varnish, dry colors |
| Rubber products | and many others |

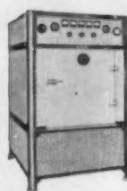
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Model AC-2a Series 200 High Sensitivity Automatic Color-Difference Meter

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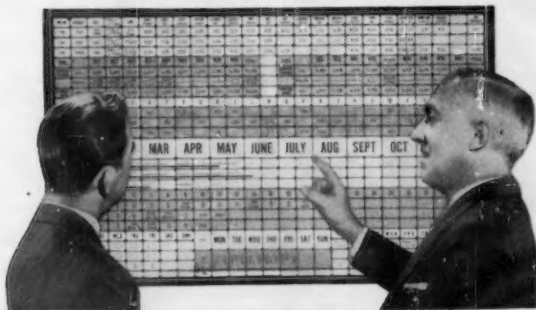
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119

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- Calibrated volt and ampere ranges:

10 mv.	1 μ a.
0.1 v.	10 μ a.
1 v.	0.1 ma.
10 v.	1 ma.
100 v.	10 ma.
- 4 times chart width zero suppression in either direction.
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YELLOW SPRINGS, OHIO

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120

LABORATORY ITEMS

(Continued from p. 118)

as an accurate and reliable means of determining compression of cored foam products in standard ASTM-RMA units.
Browning Instrument Co. 3331

High-Output Strain Gage—The first of a new line of semiconductor strain gages makes possible a variety of strain measurements. Kulite gages are available in resistance from ohms to megohms in the same physical dimensions. The Type DA-101 gage has a nominal resistance of 70 ohms and a gage factor of 115. Overall dimensions are ⅜ by ½ in. The gages come complete with nickel leads and are designed to be used in the same manner as existing wire and foil gages.
Byltrex Corp. 3332

Recording—A new recording balance, Model RM Automatic Electrobalance, has been announced. Precision is one part in 10,000 of full scale on each range. It has two ranges; 0 to 20 mg in a 15-mg container, and 0 to 100 mg in a 75-mg container. Maximum capacity is thus 175 mg, and finest sensitivity 0.002 mg.
Cahn Instrument Co. 3333

Periodic Table—A new periodic table of the elements for use in laboratories, lecture rooms, and school classrooms has been designed. The table, which is 62 in. wide and 52 in. high, includes all elements and numbers of naturally occurring radioactive and stable isotopes.
Central Scientific Co. 3334

Detection—A line of extremely sensitive "sensing elements" called MagnaFilm corrosion indicators have been developed, to detect corrosion of metal. The essential element of MagnaFilm corrosion indicators is a vacuum-deposited film of metal, 2 to 50 millionths of an inch thick. MagnaFilm indicators are available both in visual and electrical versions.
Crest Instruments 3335

Time Delay Relay—The new STR Series relay provides a unique combination of features to meet airborne and missile application requirements. The STR relay provides: instantaneous resetting, isolated load contacts, preset time delay of 20 to 180 sec, miniature size, voltage compensation, ambient temperature compensation, severe shock and vibration resistance, single-pole double-throw contacts, and is hermetically sealed.
Curtiss-Wright Corp. 3336

Differential-Transformer Indicator—Accurate indication and recording of static and dynamic values of linear motion, acceleration, force, pressure, and other quantities measurable by differential-transformer transducers is achieved with the new Model 300BF differential transformer indicator. A demodulated output, flat to 500 cps, is available for operation of cathode-ray and recording oscillographs.
Daytronic Corp. 3337

Temperature Cabinet—The controlled-temperature cabinet has undergone several important changes that make it more adaptable to a variety of operation conditions. To provide a more uniform temperature, sidewall thickness has been increased, and a positive interlock is now employed at all seams or joints. Electric heating element surface has been increased so that there is less waiting time for temperature level. The new improved thermostat regulates heat to close degree.

The new larger size observation window gives the operator a clear view of the specimen under test.

W. C. Dillon & Co., Inc.

3338

Measuring Microscope—A new 2-dimensional microscope priced at under a thousand dollars features the following specifications: scans 20 by 10 cm; reads direct to 0.01 mm; reading accuracy ± 0.01 mm; two scope objectives, 5 \times and 20 \times , and working distance 4 cm.

The Ealing Corp.

3339

Industrial Microscope—Especially made for industrial microscopy involving direct measurement, a low-cost, erect-image, low-power microscope with direct-reading scale reticle is now offered.

Edmund Scientific Co.

3340

Spin Resonance Spectrograph—A new basic laboratory research and industrial analytical instrument, the wide spectral range electron spin resonance spectrograph, is believed to be the first equipment of its kind to be offered commercially. The Electrospec 200 employs a radio-frequency approach toward the observation of electron spin resonance phenomena. It is uniquely suited to studies involving metals and water-based materials as well as semiconductors and nonconductors.

Elion Instruments, Inc.

3341

Gyratory Test Machine—The gyratory testing machine serves the dual function of kneading compactor and testing machine. It is applicable for testing bituminous mixtures, soils, and base course materials. The machine is both a compactor and a testing machine.

Engineering Development Co., Inc. 3342

Auto-Collimator—The Microptic auto-collimator reading to 0.1 sec of arc is now improved with a photoelectric system that eliminates the need for repeated observation through the eyepiece. It can be used wherever the visual instrument has been applied for precise testing of angles, circular divisions, straightness, flatness, and alignment generally. All essential optical features of the instrument have been retained.

Engis Equipment Co.

3343

Double Scanning Head—Scans simultaneously both sides of the chromatogram strip with windowless four-pi chromatogram scanner, without any gap between paper strip and sensitive detector. Slit width changeable from ⅛ to ½ in.; can be used to produce separate graphs for tritium and carbon-14, from the same chromatogram strip.

The Porro Scientific Co.

3344

Clarity Meter—A new instrument for the evaluation of optical clarity has been built. The new clarity meter provides a determination of the low-angle forward transmittance of translucent specimens. Low-angle transmittance has been shown to correlate well with visual estimates of optical clarity if the acceptance angle is very small. Source and receptor field angles in the present instrument are held below 0.2, and exceptionally rigid construction assures reproducible results.

Gardner Laboratory, Inc.

3345

Video Generator—A tri-function wide-range beat-frequency video generator (Type 1300-A) suitable for point-to-point, transient, and sweep testing has been developed. It can be used as a source for acoustic and ultrasonic tests, and testing of video systems, amplifiers,

(Continued on p. 121)

LABORATORY ITEMS

(Continued from p. 120)

discriminators, networks, and both wide and narrow-band video filters.

General Radio Co.

3346

Torsionmeter—A unique instrument called Torsionmeter to test instrument hairsprings for torque is being built. This instrument operates on the "balance" principle with the spring "zeroed in" then loaded up to 100. By moving the milligram weight a direct reading is made on the millimeter scale.

Gerbet Hairspring Co.

3347

Jet Engine Test—A new instrumentation system for jet engine test facilities has been announced. The system uses six Gilmore Model 243's, a combination digital servo indicator and recorder with a 3-in. synchronized chart drive. The system provides high-accuracy digital indication as well as integral chart recording of thrust, fuel flow, rpm, and temperature.

Gilmore Industries, Inc.

3348

Tensile Grips—A new type grip to replace those now used on common makes of physical pull testing machines is being manufactured. This new type, known as Griff Grips, features a replaceable insert. This feature does away with the practice of replacing expensive grips when worn out. Only the insert is replaced, and at a fraction of the cost of new wedge blocks.

Griff Machine Products Co.

3349

Pocket Microscope—This compact (5) in. high) and lightweight (10 oz) OMAG pocket microscope with built-in illumination, can now be supplied with a special, reticle-equipped baseplate, calibrated in thousandths of an inch.

Karl Heitz, Inc.

3350

Counters—Two new electronic counters with a wide variety of laboratory and industrial uses are now available. The counters, Models 521D and 521E, quickly and directly measure frequency and random events per unit of time. With transducers converting mechanical into electrical phenomena, they also measure such quantities as speed, rpm, rps, weight, pressure, temperature, and acceleration.

Hewlett-Packard Co.

3351

Determination of Volume—A recent invention makes possible determination of true volume as well as density, specific gravity, or porosity of solid materials whether they be porous, granular, powdery, or irregular in form. Known as Model 200, it is based upon the principle that two closed systems of air at the same pressure and temperature will have identical specific volumes.

Houston Instrument Corp.

3352

Power Supply—This instrument supplies 250 v-amp of power at either a fixed frequency of 400 cps ± 0.25 per cent or a variable frequency with a range of 350 to 450 cps. An input jack is also provided for output frequencies from 50 to 4000 cps. Output voltage is continuously variable from 0 to 120 v.

The Industrial Test Equipment Co.

3353

Voltage Regulator—The KIN-TEL Model 601A is an accurate and stable a-c voltage standard. Output voltage is from 1 to 501 v rms ac adjustable in 0.1-v steps and between 0.1-v steps by a multi-turn potentiometer. Power output capability is 5 amp up to 5 v and 25 w above 5 v. Frequencies selectable by front panel control are 60, 400, and 1000 cps.

KIN-TEL Die.

Cohu Electronics, Inc.

3354

Furnace—Dyna-Trol is a small, compact furnace which heats up to 2000 F in 1 hr; 2300 F in 1.5 hr. A constant level of temperature and infinite heat-rate control ranging from 300 to 2300 F can be maintained by means of input controllers.

L & L Mfg. Co.

3355

Stirrer—A new magnetic stirrer capable of mixing and stirring solutions in as many as six vessels at one time has been announced. A new feature of the unit, called Synchro-Drive, solves the problem of stirring several vessels simultaneously and also assures quiet operation.

Labline, Inc.

3356

Hydrogen Analyzer—This instrument combines speed and accuracy with simplicity of operation. Utilizing the hot-extraction principle, the hydrogen analyzer meets ASTM requirements (tentative procedure) of 1200-C or 2192-F operating temperature. Outgassing of a crucible is eliminated through the use of a patented, inert, blank-free susceptor.

(Continued on p. 123)

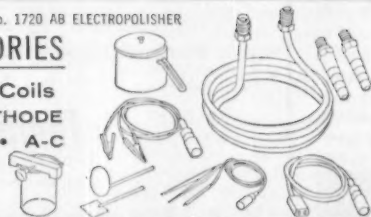
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122

LABORATORY ITEMS

(Continued from p. 121)

Another unique device allows one sample to be loaded at a time and removed from the system after extraction simply and quickly without breaking the vacuum.

Laboratory Equipment Corp. 3357

Emission Spectrophotometer—The Model 151 emission spectrophotometer is an integrated electromechanical-optical system to detect, indicate, and record on one continuous chart, spectral radiant flux density in absolute units from ultraviolet to infrared. High-sensitivity photomultipliers are used in conjunction with a Bausch and Lomb grating monochromator to provide the maximum optical and detection efficiency in measuring the spectral distribution of low-intensity light sources. Phototube spectral response is automatically corrected by an easily adjustable compensation network. The chart records for the Model 151 are directly calibrated in energy units, with a linear wavelength scale extending from 3200 to 9000 Å.

LAND-AIR, Inc. 3358

Scintillation Counter—A new well-type scintillation counter, known as Model WSC-1, is said to have the lowest background count of any such instrument now commercially available. With a background as low as 125 counts per minute under average conditions, it makes possible more precise detection of low-level gamma activity in test tube or flat-type samples.

Nuclear Measurements Corp. 3359

Gaussmeter—Uses rotating probe coil to develop an a-c voltage proportional to the magnetic field, compares this against the voltage from a local reference generator in a null-deflection circuit.

Rawson Electrical Instrument Co. 3360

Tracer Element—Availability of four new carbon-14 labeled radiochemicals is announced. They are 1-butene-1-C¹⁴ and hexamethyl-C¹⁴ benzene that are of interest to chemists working with hydrocarbons; 4-(2,4-dichlorophenoxy) butyric-1-C¹⁴ acid will interest those studying plant growth regulators, and tripalmitin (glyceryl-1,3-C¹⁴) is useful in the chemistry of fatty acids.

Research Specialties Co. 3361

Engine Test Equipment—A new test bench for checking out jet aircraft fuel nozzle and manifold assemblies is being built. Based on Pratt & Whitney Aircraft Div. procedures for testing JT-3 and JT-4 engines, the test bench was designed large enough to accommodate complete fuel manifolds from these engines.

REF Manufacturing Corp. 3362

Oxygen Measurement—The Magnox analyzer, a unit for the continuous measurement of oxygen in gases, has automatic temperature compensation. With an accuracy of ± 1 per cent to 2 per cent of full scale and a stability of ± 1 per cent of full scale over more than a year, the Magnox analyzer provides accurate data for efficient fuel burning, permits economical ceramic firing and closer control of kiln atmospheres, measures the purity of oxygen and of nitrogen.

Milton Roy Co. 3363

Strip Chart Recorder—An easy-to-install, kit-form printing device called the Identichart RI-5 automatically prints

date, time (to the nearest minute), and remotely selected code number or letter on strip charts for quick, accurate identification and interpretation of time or sequence in which conditions occur, without the need for someone to watch charts and make identification marks.

Royson Engineering Co. 3364

Kerosine Equivalent Apparatus—A new centrifuge kerosine equivalent apparatus (CKE) for measuring surface capacity, including absorption, of both coarse and fine aggregates used in bituminous mixtures is available. The new apparatus is also used to determine an index (K factor) which indicates the relative particle roughness or degree of porosity.

Soiltest, Inc. 3365

Moisture-Density Gage—The d/M gage is designed to measure moisture content and density of soil and similar materials. It has wide application in the road building and construction industry. The d/M gage design is based on the laws of absorption, scattering, and reflection of gamma rays and neutrons.

Soiltest, Inc. 3366

Hardness Tester—Because it can be fitted with an electromagnetic or chain clamp, the British-made Indentometer (portable hardness tester) can make Rockwell tests in the factory or the field. A hydraulic pressure unit applies a minor load of 10 kg and a major load up to 150 kg for normal Rockwell-testing procedures. Readings are direct in Rockwell A, B, or C scales.

Steel City Testing Machines, Inc. 3367

Timing Device—A new and improved timing device is now being used on Model TSS-31 test sieve shaker. The TSS-31 also features an improved vibrating drive unit which provides positive vertical and rotating horizontal movements which combine to make separation through the various screens more rapid.

Syntron Co. 3368

Hot Plates—A new series of hot plates featuring a newly designed thermostatic control unit that provides close, stepless control of temperature from 10 F above ambient to 700 F is announced. Type 2200 hot plate consists of four models in two sizes, 12 by 12 in. and 12 by 24 in., each for either 115 or 230-v operation.

Thermo Electric Mfg. Co. 3369

High-Vacuum Electronic Pump—Applicable to a broad range of uses, from vacuum-tube processing to incorporation into scientific instruments, the new Series 240 UlteVac high-vacuum pump is a general-purpose unit with a 40-liter per sec capacity. Operating on a cold-cathode discharge within a magnetic field, the Series 240 has no moving parts and the modular internal structure is easily removed for maintenance or replacement.

ULTEK Corp. 3370

Fluoroscopic Screen—A new-type fluoroscopic screen called RAD-A-LERT, which enables radiologists to detect unabsorbed stray radiation, has been announced.

United States Radium Corp. 3371

Dial Thermometers—Mercury-actuated dial thermometers for piping installations feature ease of reading and dependable accuracy throughout the working range, uniform graduating scale for the entire range, a micrometer adjustable pointer,

(Continued on p. 124)

FASTER, EASIER WAY to determine petroleum hydrocarbon types by the F-I-A method



Jarrell-Ash Phillips
"Chromanalyzer"

U-V CHROMATOGRAPHIC ANALYZER

Developed specially for the ASTM D-2 Fluorescent Indicator Adsorption Method, the Jarrell-Ash Phillips "Chromanalyzer"® enables the petroleum analyst to determine aromatic, olefinic, and saturated hydrocarbons more rapidly and conveniently than possible with existing F-I-A apparatus.

- Shorter (3-foot) columns require less transit time; are less fragile, easier to fill and clean.
- Operates under normal room lighting — no darkroom required.
- Uniform, standardized ultraviolet illumination — twin "blacklight" tubes always at fixed distance and angle.
- Boundary points mechanically recorded in ink on strip chart.
- Compact, self-contained instrument occupies only 16" x 25" of bench space.
- Accommodates up to eight samples.

Write for detailed literature and
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LABORATORY ITEMS

(Continued from p. 123)

and an all-stainless-steel system for quick response and long life.

Weksler Instruments Corp.

3372

Recorder—Release of the versatile, YSI Model 80 laboratory recorder is announced. The Model 80 has 5 full-scale calibrated voltage ranges, (10 and 100 mv; 1, 10, and 100 v) and 5 full-scale calibrated current ranges (1, 10, and 100 μ a; 1 and 10 ma). Its attenuator allows continuously variable full-scale deflections between calibrated ranges. The Model 80 can be operated as a zero-left, zero-center, or zero-right recorder and provides 4 times full-chart width expansion on all ranges.

Yellow Springs Instrument Co., Inc.

3373

MATERIALS NEWS

Refractory—A new ram mix having a tabular alumina base and an alumina content of 98 per cent has been announced. This heat-setting material, known as Pli-Tab Ram-Mix, has been designed for such applications as induction-melting steel furnaces and vacuum-melting aluminum furnaces. It is highly effective for temperatures up to 3500 F. Temperature service range extends from 500 to 3500 F. Pli-Tab Ram-Mix weights 180 lb per cu ft in place.

Plibrico Co., Chicago, Ill.

Liquid Sapphire—Two new electronic semiconductor grades of levigated alumina abrasives are announced. These abrasive

crystals meet the critical requirements of the electronic and semiconductor industry and will produce the ultrahigh-polished surfaces necessary for advanced device fabrication.

Geoscience Instruments Corp., New York, N. Y.

Thermal Insulation Cement—A new product in the field of thermal insulation is a castable, quick-set, one-coat insulation cement. It is unique in the fact that, without shrinkage, it can be packed by hand, troweled, injected, palmed, sprayed, or poured to any thickness. A remarkable feature of this cement is reuse of the set or dried material. Complete brochure sent on request.

Thermold Products Co., Grandview, Mo.

INSTRUMENT COMPANY NEWS

W. & L. E. Gurley, Troy, N. Y.—Robert G. Betts has been elected president of W. & L. E. Gurley. Mr. Betts is the sixth president in Gurley's 115-year history. He also continues as treasurer.

High Voltage Engineering Corp., Burlington, Mass.—A new physics research laboratory for basic and applied neutron studies is announced by High Voltage Engineering Corp. The facility will conduct investigations in activation analysis and will provide neutron output data as well as information on target life and design to industry, government, and educational institutions. In addition, the laboratory will carry out basic programs in areas of potential interest to industry, using a 2-Mev Van de Graaff positive ion particle accelerator specially fitted for neutron work. Applications of im-

mediate concern include use of the accelerator in surface analysis studies, wear and corrosion investigations, and related projects where positive ions and neutrons have shown promise as research tools for the metallurgical field.

Rotek Instrument Corp., Cambridge, Mass.—Rotek Instrument Corp. has been formed by Samuel Ochlis and Peter Richman to develop and manufacture high-precision transistorized instruments for electronic test and development laboratories. A wide range of product lines within several major areas of precision instrumentation is now under development by the new corporation. Stress is placed on achieving highest precision and ultimate reliability for the equipment, which is being designed to operate under wide environmental extremes, permitting field measurements with true laboratory accuracies.

Soiltest, Inc., Chicago, Ill.—Has announced the organization of a subsidiary, Soiltest International S.A. of Lausanne, Switzerland. Theodore W. Van Zelt, Soiltest president, announces that the Swiss corporation will direct sales and distribution for the company's European, African, and Middle Eastern markets.

Thwing-Albert Instrument Co., Philadelphia, Pa.—Miss R. A. Jago, president of Philadelphia's 60-year old Thwing-Albert Instrument Co., announces the election of John Facht as vice-president, manufacturing; Ralph E. Green, vice-president, technical sales and quality control; and Charles A. Paul, Jr., as secretary.

OTS Research Reports

THESE REPORTS, recently made available to the public, can be obtained from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Order by number.

Proposed Simplified Practice Recommendation for Acoustical Material, available on request from Commodity Standards Division, OTS, U. S. Department of Commerce, Washington 25, D. C.

Commercial Standard CS227-59, Polyethylene Film, Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C. 15 cents.

Translations of Russian Air Pollution Studies Published (USSR) Book 1, OTS 59-21173, \$2.75, Book 2, OTS 59-21174, \$3.; and Book 3, OTS 59-21175, \$3.

A Mass Spectrometer System for Materials Research Summary Report, Phase I, PB 161073, \$1.

Metal-Ceramic Receiving Tubes for Automatic Production, PB 151919, \$1.75.

Electron Tube Bulb Temperature Ratings, PB 151830, \$2.

Development Z-5219 100-Watt CW S-Band TWT, PB 151958, \$1.25.

Tensile Properties of Aircraft-Structural Metals at Various Rates of Loading After Rapid Heating, PB 151895, \$3.

Stress Distribution in a Plate with a Hole Subjected to an Axial Load and Creep, PB 161035, 75 cents.

Creep Deformation in a Single Riveted Structural Joint Under Axial Tension, PB 161036, 50 cents.

An Emission Spectrographic Method for the Analysis of Zinc-Base Die Castings, PB 151175, 75 cents.

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CIRCLE 595 ON READER SERVICE CARD

Federal Government Standards Index Changes

THE FEDERAL Supply Service of the General Services Administration is charged with the responsibility for establishing specifications to be used by the Federal Government for Procurement of materials and supplies. The GSA issues an annual Index of Initiation of Federal Specifications Projects, and monthly supplements.

The items listed below appeared in Supplements 10 and 11 for December, 1959, and January, 1960.

INITIATIONS

Title	Type of Action	Symbol or Number	FSC Class	Assigned Agency & Preparing Activity
(Supplement 10, December, 1959)				
Colors.....	Int. Change	Fed. Std. No. 595	8010	DOD-Army-CE
Acacia, Technical (Gum Arabic).....	Rev.	JJJ-A-20a	6810	DOD-Army-CE
Bindings, Cotton, Bias-Cut.....	Rev.	DDD-B-331c	8305	DOD-Army-QMC
Carpets and Rugs, Axminster.....	Rev.	DDD-C-51c	7220	GSA-FSS
	New	DDD-C-0051b (GSA-FSS)		
Carpets and Rugs, Wilton.....	Rev.	DDD-C-71c	7220	GSA-FSS
	New	DDD-C-0071b (GSA-FSS)		
Cloth, Cotton, Broadcloth, Mercerized.....	Rev.	CCC-C-437b	8305	DOD-Army-QMC
Cloth, Cotton, Bunting, M.....	Rev.	CCC-C-439b	8305	DOD-Army-QMC
Cloth, Cotton, Cheesecloth, Bleached and Unbleached.....	Rev.	CCC-C-440a	8305	DOD-Army-QMC
Cloth, Cotton, Crash and Cloth, Cotton-Linen Crash (Toweling).....	New	CCC-C-410	8305	DOD-Army-QMC
Cloth, Cotton, Damask.....	New	CCC-C-413	8305	DOD-Army-CE
Cloth, Cotton, Duck, Bleached.....	Rev.	CCC-C-442a	8305	DOD-Army-QMC
Cloth, Cotton, Osnaburg.....	Rev.	CCC-C-423a	8305	DOD-Army-QMC
Cloth, Cotton, Seersucker.....	Rev.	CCC-C-448b	8305	DOD-Army-QMC
Cloth, Cotton, Ticking, Twill.....	New	CCC-C-436	8305	DOD-Army-QMC
Cloth, Jute (or Kenaf), Burlap.....	Rev.	CCC-C-467a	8305	DOD-Army-QMC
Cloth, Window Shade.....	Rev.	CCC-C-521c	8305	DOD-Army-QMC
Magnesium Alloy, Sand Castings.....	Rev.	QQ-M-56a	9650	DOD-Navy-Aer
Paper, Blotting.....	Am. 1	UU-P-63c	7530	GSA-FSS
Paper, Bond & Writing, White & Colored.....	Rev.	UU-P-121i	7530	GSA-FSS

(Supplement 11, January, 1960)

Metals Test Method (Method 241.1 (241.2 in error) (Hardness Conversion Tables for Steel).....	Rev.	Fed. Test Method Std. No. 151	...	DOD-Navy-Ord
Rubber Bands.....	Rev. (Prop.)	Fed. Std. No. 58	...	GSA-FSS
Aluminum Alloy 1100 (2S), Plate and Sheet.....	Rev.	QQ-A-561c	9530 9535	DOD-Navy-Ships
Aluminum Alloy Bars, Rods, and Structural and Special Shaped Sections, Extruded, 6063 (53S).....	Rev.	QQ-A-274a	9530 9535	DOD-Navy-Ships
Aluminum Alloy Sand Castings.....	Rev.	QQ-A-601c	...	DOD-Army-ORD
Chemicals, Analytical, General Specification for.....	New	O-C-265	6810	DOD-Army-CE
Chemicals, Dry and Paste, Packaging and Packing of.....	New	PPP-C-301	6810	DOD-Army-CE
Cloth, Cotton, Corduroy.....	Rev.	CCC-C-441a	8305	DOD-Army-QMC
Cloth, Cotton, Duck; Fire, Water, Weather, and Mildew Resistant.....	Am. 1	CCC-C-428a	8305	DOD-Army-QMC
Drums, Metal, 55 and 110 Gal (for Flammable or Poisonous Liquids).....	New	PPP-D-726a PPP-D-00726 (COM-BDSA)	8110	COM-BDSA
Drums, Metal, 55 and 110 Gal (for Flammable Solids or Oxidizing Materials).....	New	PPP-D-741a PPP-D-00741 (COM-BDSA)	8110	COM-BDSA
Fabric, Nonwoven.....	Rev. Int.	CCC-F-46b CCC-F-0046a (GSA-FSS)	7920	GSA-FSS

WITHDRAWALS

Title	Type of Action	Symbol or Number	Assigned Agency or Technical Committee	Reason for Withdrawal
(Supplement 11, January, 1960)				
Bags, Net, Laundry, Cotton.....	Rev.	JJ-B-61a	DOD-Army-QMC	Pending additional information as to the need for specification
Plastic Sheet, Vinyl (for Wall Covering).....	Rev.	LP-00522 (COM-NBS)	COM-NBS	Pending acceptance assignment
Thread, Cotton.....	Am. 2	V-T-276d	GSA-FSS	To be replaced by revision of V-T-276d



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CIRCLE 597 ON READER SERVICE CARD

TITLE CHANGES

Title	Type of Action	Symbol or Number	Former Title
(Supplement 10, December, 1959)			
Cloth, Cotton, Ticking, Twill....	New	CCC-C-436	Ticking, Mattress and Pillow

(Supplement 11, January, 1960)			
Tape, Friction.....	Rev.	HH-T-00101b (Navy-Ships)	Insulating Tape, Electrical, Friction

REASSIGNED PROJECTS

Title	Type of Action	Symbol or Number	FSC Class	Former Assigned Agency	Reassigned To
(Supplement 11, January, 1960)					
Hand Cleaner, Duplicating Ink; Hand Cleaner Grease.....	New	P-H-31	8520	GSA-FSS	DOD-Army-QMC

PROMULGATIONS

Title	Type of Action	Symbol or Number
(Supplement 10, December, 1959)		
Paper, Bond and Writing White and Colored.	Rev.	Fed. Std. No. 53J
Soap and Soap-Products (Including Synthetic Detergents): Sampling and Testing.....	Chg. Notice 1	Fed. Test Method Std. No. 536
Steel: Chemical Composition and Hardenability.....	Rev.	Fed. Std. No. 66b
Cleaning Compound, Toilet Bowl.....	Am. 3	O-C-426d
Cloth, Cotton, Duck; Fire, Water, Weather, and Mildew Resistant (Superseding CCC-C-00428 (Army-QMC) and CCC-D-748).....	New	CCC-C-428a
Distilling Apparatus, Laboratory With Graham Condenser (Superseding GG-D-00461 (HEW-PHS) and GG-D-461a).....	Rev.	GG-D-461c
Enamel, Alkyd, Semi-Gloss (Superseding TT-E-529).....	Rev.	TT-E-529a
Hose, Rubber, Water (Yarn Reinforced).....	Am. 1	ZZ-H-601a

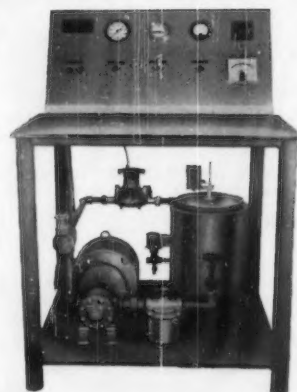
(Continued on page 129)

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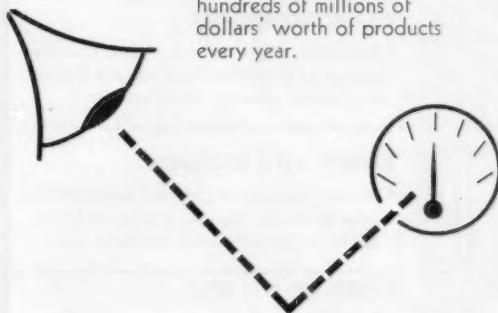
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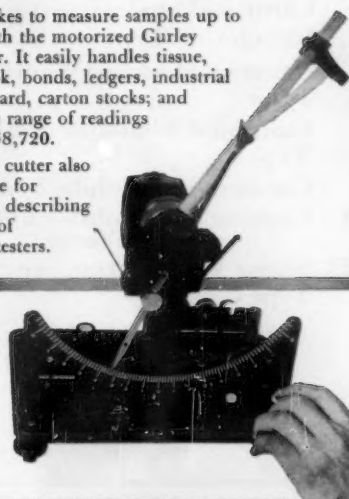
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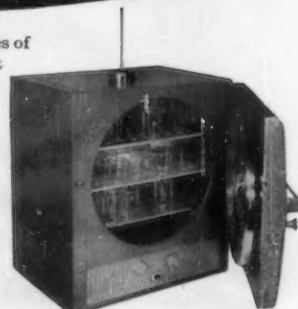
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CIRCLE 608 ON READER SERVICE CARD

FEDERAL GOVERNMENT STANDARDS

(Continued from page 126)

SPECIFICATIONS AND STANDARDS APPROVED FOR PRINTING

Title	Type of Action	Symbol or Number
(Supplement 10, December, 1959)		
Towels, Paper.....	Rev.	Fed. Std. No. 7b
Antifreeze, Ethylene Glycol, Inhibited.....	Am. 1	O-A-548a
Blanket, Bed, Other Than All-Wool.....	Rev.	DDD-B-421d
Butyl Acetate, Secondary (for Use in Organic Coatings).....	Rev.	TT-B-840b
Cloth, Cotton, Ticking, Twill.....	New	CCC-C-436
Drum: Metal Shipping, Steel, Lightweight (55 Gal- lon).....	Rev.	PPP-D-771b
Paperboard, Wrapping, Cushioning.....	Am. 2	PPP-P-291a
Pine Tar, Technical.....	Am. 1	LLL-P-430a
Pipette, Dropping: Glass and Plastic.....	New	DD-P-355
Printing and Stationery Paper, Packaging and Pack- ing for Domestic and Overseas Shipment.....	Am. 2	PPP-P-25b
Roll, Cotton-Tape.....	New	DDD-R-630
Sheet, Bed (Cotton).....	Rev.	DDD-S-251a
Ticking, Mattress and Pillow.....	Canc.	GGG-T-351
Tricresyl Phosphate.....	Am. 1	TT-T-856a

(Supplement 11, January, 1960)

Artificial Leather, Cloth, Coated, Vinyl Resin (Up- holstery).....	Rev.	CCC-A-700b
Bearing, Sleeve (Bronze, Plain or Flanged).....	New	FF-B-195
Box, Fiberboard.....	Rev.	PPP-B-636b
Enamel, Odorless, Alkyd, Interior, High-Gloss, White and Light Tints.....	New	TT-E-505a
Feathers, Waterfowl and Down, Waterfowl.....	Am. 1	C-F-160a
Mucilage.....	Am. 1	MMM-M-792b

CANCELLATIONS

Title	Symbol or Number	Reason for Cancellation
(Supplement 10, December, 1959)		
Acid, Nitric, Technical Grade.....	O-A-58	Superseded by O-N-350
Duck, Cotton; Fire, Water, and Weather Re- sistant.....	CCC-D-746	" " CCC-C-428a
(Supplement 11, January, 1960)		
Gauge, Wire (for Laboratory Use).....	RR-G-123	" " RR-G-675
Venetian-Red, Dry (Paint-Pigment).....	TT-V-226	" " TT-P-457

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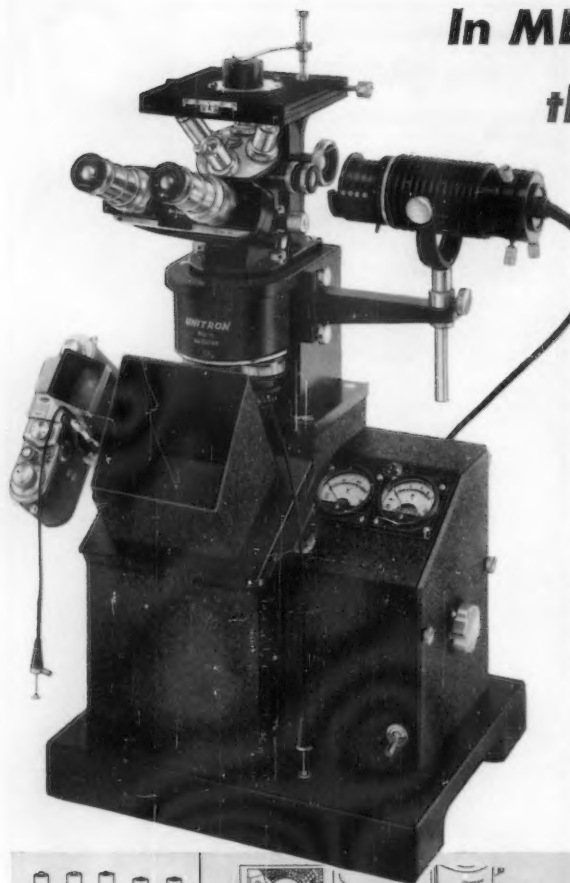
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In METALLOGRAPHS...

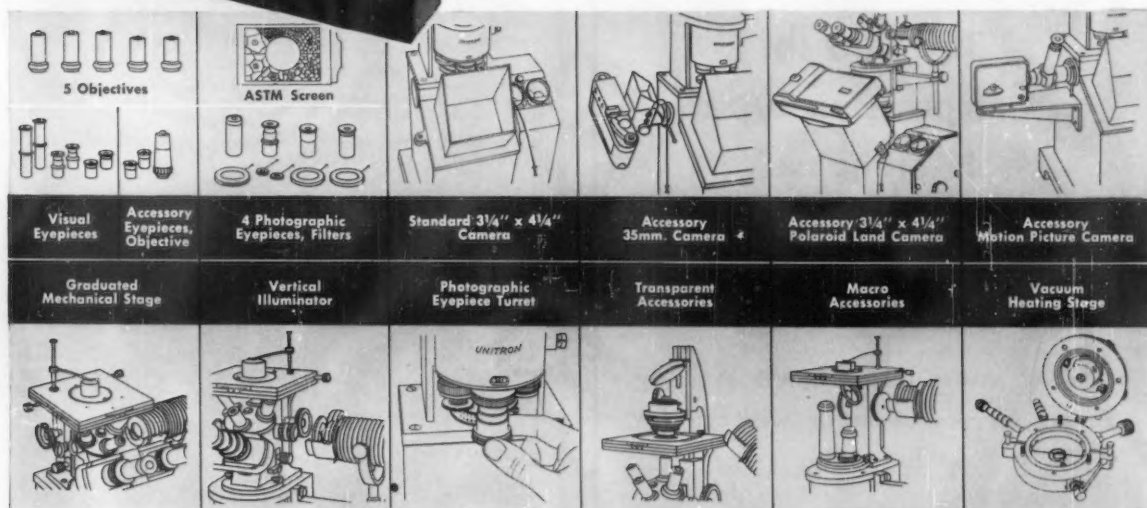
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UNITRON's Metallograph and Universal Camera Microscope Model BU-11 with binocular eyepiece; objectives: M5X, M10X, M40X, 40X for transmitted light, 100X oil immersion; paired visual eyepieces: R5X, Ke10X Micrometer, Ke15X; photo eyepieces: 10X, 15X, 20X, Micrometer; etc., as described above.

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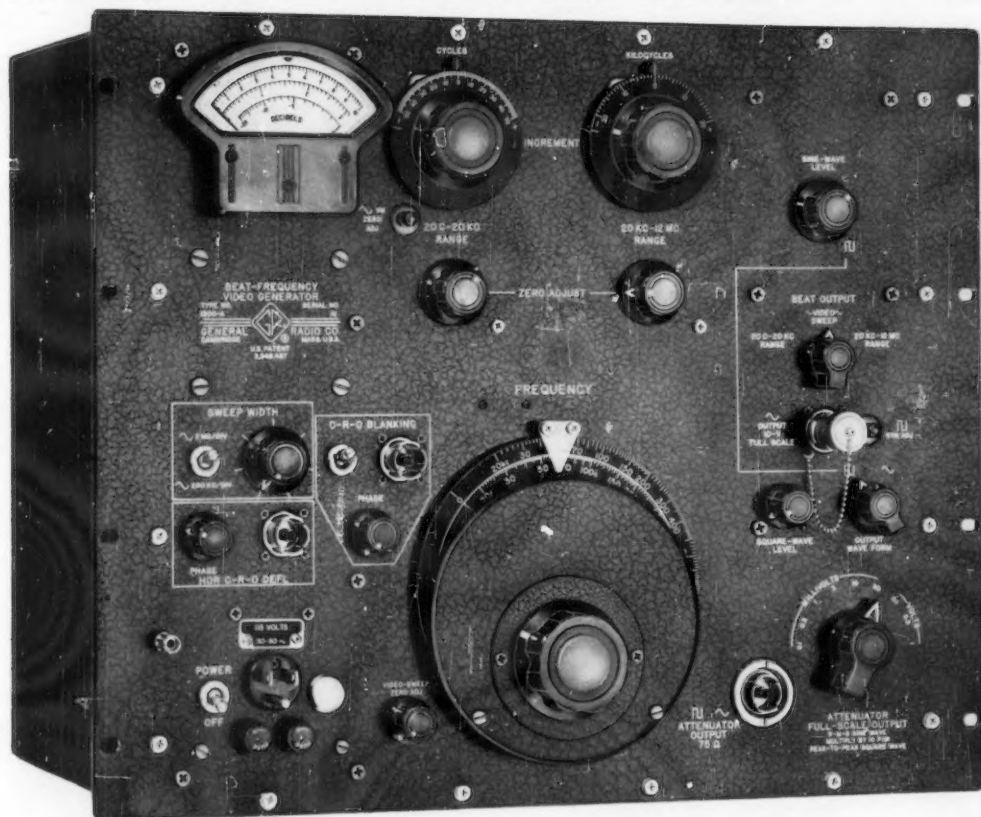
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NEW 20c to 12-Mc Beat-Frequency Generator for Sine/Square-Wave and Sweep Applications



The features of beat-frequency generators, so well liked for audio-frequency testing, are now available for ultrasonic and video-frequency work. Features include: complete audio- or video-band coverage in one sweep of the dial without annoying range switching... high resolution provided by incremental frequency dials for accurate point-by-point studies of amplitude peaks and dips... continuously adjustable electronic sweep for video measurements at center frequencies to 12 Mc... automatic graphic-level and x-y recording with accessory G-R Dial Drives... square-wave output for frequency-response testing by transient techniques (e.g., rise-time and ramp-off measurements)... adjustable ± 6 -Mc sweep at center frequencies from 36 to 42 Mc (obtained directly from internal oscillators) for television i-f testing.

This instrument's many outputs and different modes of operation, coupled with excellent frequency stability and high output (10v) over the entire frequency range, make it the most versatile audio-video test instrument commercially available.

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Type 1300-A Beat-Frequency Video Generator... \$1950.

As Manually-Tuned Generator:

Sine Wave: 20c to 12 Mc
Square Wave: 20c to 2 Mc

As Sweep Generator (50c sweep rate):

Sine Wave: 20 kc to 12 Mc
Sweep width is continuously adjustable from 0 to ± 6 Mc at any center frequency from 0 to 12 Mc.
Horizontal deflection voltage and blanking pulse provided for scopes.

Calibration Accuracy:

20c to 20 kc: $\pm(1\% + 1c)$
20 kc to 500 kc: $\pm(2\% + 1 kc)$
500 kc to 12 Mc: $\pm(1\% + 1 kc)$

In addition to the main frequency dial, two increment dials calibrated from $-50c$ to $+50c$ and $-20 kc$ to $+20 kc$ are provided. Calibration accuracies are $\pm 1c$ and $\pm 0.5 kc$, respectively.

Sine Wave—harmonic distortion
20c to 20 kc: $< 1.5\%$ of output
20 kc to 12 Mc: $< 4\%$ of output

Square Wave—rise time less than $0.075 \mu sec$ above 300 kc
Top flat to 2% of peak-to-peak at 60c, 5% at 20c

Hum: less than 0.1% of output

	Voltage Range		Accuracy	Frequency Characteristic	Output Impedance
	Sine-Wave (rms)	Square-Wave (peak-to-peak)			
Attenuator output	0.1, 0.3, 1, 3, 10, and 30 mv; 0.1, 0.3, and 1 v full scale, open circuit	1, 3, 10, 30, 100, and 300 mv; 1, 3, and 10 v full scale, open circuit	$\pm 3\%$ of full scale; attenuator db increments $\pm 1\%$	flat within ± 0.25 db from 40c to 20 kc (± 0.75 db at 20c); ± 1 db from 20 kc to 12 Mc	75 $\Omega \pm 2\%$
High output	0 to 10v	0 to 10v	$\pm 3\%$ of full scale	flat within ± 0.25 db from 20c to 20 kc; ± 1 db from 20 kc to 12 Mc (open circuit)	820 $\Omega \pm 2\%$

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